University of Alberta
Printing Department

THE UNIVERSITY OF ALBERTA

A STUDY OF THE THICKNESS OF DENSITY CURRENTS IN RESERVOIRS

by

MANGAL DASS CHAWLA, B.A., B.Sc.Eng. (Punjab - INDIA)

A THESIS

Submitted to the FACULTY OF GRADUATE STUDIES

In Partial Fulfillment of the Requirements for the

Degree of

MASTER OF SCIENCE

DEPARTMENT OF CIVIL ENGINEERING

EDMONTON, ALBERTA

December, 1964

UNIVERSITY OF ALBERTA

FACULTY OF GRADUATE STUDIES

The undersigned certify that they have read and recommend to the FACULTY OF GRADUATE STUDIES for acceptance, a thesis entitled "A Study of the Thickness of Density Currents in Reservoirs" submitted by Mangal Dass Chawla, in partial fulfillment of the requirements for the degree of Master of Science.

DATE: December 21, 1964

ABSTRACT

This thesis summarizes an investigation of the pertinent parameters that govern density currents in reservoirs and attempts to establish a rule that correlates them.

Density currents were produced with salt and aluminum silicate and propagated through clear water in a flume. The flume was kept level for the first few runs with both the materials. These tests were repeated at two different slopes.

The apparatus used for the present study and the experimental techniques are described in detail. Various theories of stratified flow which formed a background of this work are examined.

The friction factor of the density layer, λ, was found to depend primarily upon the Reynolds number of the density layer and on the non-dimensional thickness of the layer.

ACKNOWLEDGEMENTS

This resume was conducted through a Canadian Commonwealth Scholarship grant. The author expresses his thanks to the Scholarship Committee, and also to the Government of Punjab (INDIA) for the grant of study leave. Professor John B. Nuttall supervised the research and the writing of the thesis. He made many constructive suggestions during the building up of the equipment. Professor A. W. Peterson was a great help in the laboratory. Dr. T. Blench inspired the author by his keen interest in this study. Mr. Garry Harreuther helped in the construction of the Conductivity Probes and Wheatstone Bridge circuits. Mr. David McGowan helped the author in building up the additions to the flume for the proposed study. To these persons the author expresses his sincere thanks. The author is also obliged to Professor S. Thomson and Mr. Brian Clarke of the Research Council of Alberta for offering assistance in the tests run in the Soils Laboratory.

My thanks are also due to Mrs. Esther Stewart and my wife, Mrs. Santosh Chawla, who did the typing and proof reading respectively of the manuscript.

TABLE OF CONTENTS

APPENDIX | Page

LIST OF FIGURES

LIST OF PHOTOGRAPHS

LIST OF NOMENCLATURE

B	- Breadth of flume or reservoir in feet.
c	- Salinity concentration, % by weight.
D	- Total depth of flow in feet.
d	- Thickness of density layer in feet.
d_1	- Thickness of interlayer in feet.
D	- Thickness of top layer in feet.
g'	- $\frac{\Delta \rho}{\rho + \Delta \rho} g$
F	- Froude number of the total depth of flow, $V_b / \sqrt{g' D}$
F_b	- Froude number of the density layer, $V_b / \sqrt{g' d}$
g	- Acceleration due to gravity in feet per sec^2.
H	- Head over the weir in feet.
h	- Head over weir on downstream side in feet.
K	- Viscometer constant.
n''	- Slope of θ VS N on a log-log paper.
N	- Revolutions per minute in viscosity tests.
q	- Discharge over weir in cubic feet per second.
R	- Reynolds number of the total depth of flow, $V_b D/\nu_b$.
R_b	- Reynolds number of the bottom layer, $V_b d/\nu_b$.
s	- Specific gravity of aluminium silicate.
S	- Bed slope.
T	- Temperature in $^{\circ}F$.
V_b	- Mean velocity of density layer in feet per second.

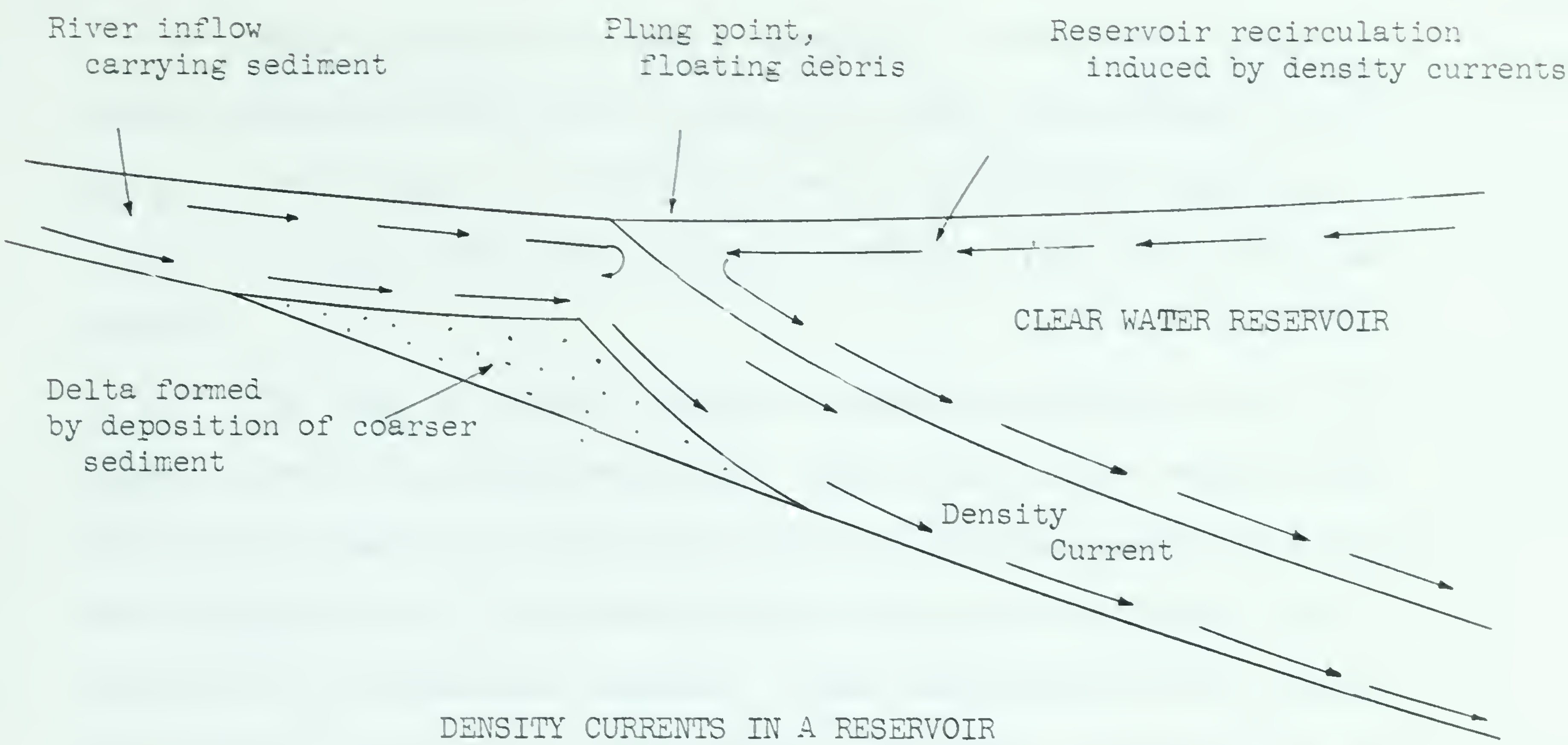
V	- Mean velocity of top layer in feet per second.
V_i	- Velocity at the interface.
ρ	- Mean density of top layer, slugs/ft.^{3}
$(\rho + \Delta\rho), \rho'$	- Mean density of density layer, slugs/ft.^{3}
τ_o	- Shear stress at the bed and sides.
τ_i	- Shear stress at the interface.
τ	- Shear stress as used in viscosity measurements.
λ_o	- Coefficient of friction at the bed and sides, $\tau_o/(\rho+\Delta\rho)V_b^2/2$
λ_i	- Coefficient of friction at the interface, $\tau_i/(\rho+\Delta\rho)V_b^2/2$
λ	- Coefficient of total friction, $\lambda_o + \lambda_i/(1-d/D)$
τ_y	- Yield stress of the material.
α_1	- Momentum correction factor.
ϕ	- Multiplier of free flow discharge for submerged weir.
α	- τ_i/τ_o
J	- $F_b^2/R_b \cdot S$
μ	- Coefficient of viscosity of top layer, c-Poises.
μ_b, μ'	- Coefficient of viscosity of the bottom layer, c-Poises.
μ_a	- Apparent viscosity of clay suspensions, c-Poises.
ν_b, ν'	- Kinematic viscosity of the bottom layer, ft.^{2}/sec.
θ	- Deflection in degrees of viscometer, in viscosity tests.
Λ	- Deflection of oscillographic recorder in cms.
du/dr	- Velocity gradient.
d(d)/ds	- Slope of the density layer.
c.f.s.	- Cubic feet per sec.
r.p.m.	- Revolutions per minute.

CHAPTER I

1.1 INTRODUCTION

Density currents occur when flowing fluids of slightly different densities come in contact with each other. Causes of small density difference include temperature variation as in the atmosphere and deep reservoirs, salinity as in the sea and variation in sediment concentration as in lakes and reservoirs. Many authors have given different definitions to this type of flow. Howard (1953) has quoted several in his paper. The National Bureau of Standards, U.S.A., states that "A density current is the movement, without loss of identity by turbulent mixing at the bounding surfaces, of a stream of fluid, under, through or over a body of fluid with which it is miscible and the density of which varies from that of the current, the density difference being a function of the differences in temperature, salt content and/or silt content of the two fluids."

Density currents are referred to by various names in the literature, for example turbidity currents, stratified flows, density flows, underflows etc. Density currents present problems to engineers in the penetration of salt water in fresh water estuaries or in the silting of reservoirs. It has been observed that when a stream having large amounts of very fine particles in suspension discharges into a reservoir of relatively clear water, then, because of the greater density the turbid water sinks to the bottom and flows along the bed of the reservoir until it reaches the dam.



DENSITY CURRENTS IN A RESERVOIR

(Figure taken from Ref. 13)

After reaching the dam, the density currents start spreading and depositing sediment. Lane (1947) found that density currents move many miles down a reservoir without any indication on the surface. In the Elephant Butte Reservoir in New Mexico they have been known to flow 30 to 40 miles and in Lake Mead about 70 to 90 miles.

Knowing the average sediment concentration, width, depth and the mean velocity of flow of the density currents, the rate of sediment transport can be calculated. To give an idea of this rate, say

Width of density currents	=	1000 ft.
Depth of density currents	=	20 ft.
Mean Velocity	=	0.2 ft./sec.
% Average concentration by weight	=	0.5
∴ Sediment rate	=	$1000 \times 20 \times 0.2 \times 62.4 \times \frac{0.5}{100}$
	=	1248 pounds per second
Weight of sediment discharge	=	48137 tons per day.

Howard (1953) stated that in Lake Mead, of the total volume of sediment deposited in the first 14 years of storage, about 65% was due to density currents alone. An interesting feature of this large percentage is that the deposits have about one quarter the dry bulk density of delta material.

The study of density currents is needed, since these affect the storage volume in lakes and reservoirs. Their study is also necessary for the practical operation of reservoirs, because sometimes industries discharge their chemical wastes into reservoirs which are used for municipal water supplies or for recreational purposes. Again, sometimes cold water needed for condenser plants or for cooling certain processes in industries, can be economically drawn from the reservoirs by siting the inlets properly. These tasks could be better accomplished if the behaviour of density currents was better understood.

1.2 Present Problem

The problem under investigation is to study the thickness of density currents and the different parameters which affect this thickness.

1.3 Conditions of this Study

The study has been carried out under the following conditions:

1. With either salt or aluminium silicate (clay) of grain size distribution shown in figure D-6 .

2. With the flume horizontal; at a slope of 1 in 360, and at a slope of 1 in 180.

3. The discharges, concentrations, and depths of flows were as listed in the following table:

Test Run	Discharge/foot Width of flume c.f.s.	Initial Concentration of Salt Mixture in Head Tank % by Weight	Initial Specific Gravity of Clay Mixture in Head Tank	Depth of flow in Flume at Start ft.
1	0.0203	0.455	-	0.578
2	0.0323	1.000	-	0.601
3	0.0092	-	1.0024	0.559
4	0.0203	-	1.0068	0.565
5	0.0107	-	1.0075	0.539* - 0.801/
6	0.0023	2.080	-	0.501* - 0.764/
7	0.0017	2.000	-	0.610* - 1.119/
8	0.0049	-	1.0070	0.636 - 1.147/

4. The effect of variation in temperature with depth was ignored.

* Depth of flow at section 1 (Refer Figure A-1)
/ Depth of flow at section 6 (Refer Figure A-1)

CHAPTER II

2. RESUME OF ANALYTICAL LITERATURE

Researches of density currents in lakes in North America date from 1937 when a committee was formed by the Division of Geology and Geography of the National Research Council of U. S. A. under the chairmanship of Herbert N. Eaton. This committee formulated plans to study Elephant Butte Reservoir on the Rio Grande and Lake Mead on the Colorado (Howard, 1953).

Since then various attempts have been made to study different aspects of density currents. The status of present quantitative knowledge and analysis seems to be fairly represented by the following works.

Raynaud (1951) assumed uniform flow of density currents and derived the following equation for the mean velocity of flow in the density layer:

$$V_b^2 = \frac{8}{\lambda} \cdot g' \cdot R_H \cdot S$$

where V_b = Mean velocity of the density layer.

$$g' = \frac{\Delta \rho}{\rho + \Delta \rho} \cdot g$$

where ρ = Density of the top layer.

$\rho + \Delta\rho$ = Density of the bottom layer.

g = Acceleration due to gravity.

$$\lambda = \lambda_o + \lambda_i \cdot \frac{\ell}{\ell + 2d}$$

λ_o = Coefficient of friction at the bed and sides.

λ_i = Coefficient of friction at the interface.

ℓ = Width of flow.

d = Thickness of density layer.

$R_H = \dfrac{\ell . d}{\ell + 2d}$ = Hydraulic Radius.

S = Bed slope.

He also studied the dependence of λ on Reynolds number R_1 and found that the relationship in the laminar range to be

$$\lambda = \frac{225}{R_1}$$

$$\text{where } R_1 = \frac{4\ V_b \cdot R_H}{\nu_b}$$

where ν_b = kinematic viscosity of the bottom layer. Raynaud found that the shear stresses at the bed and sides, and the interface are

$$\tau_o = 4.30\,\mu_b \cdot \frac{V_b}{d}$$

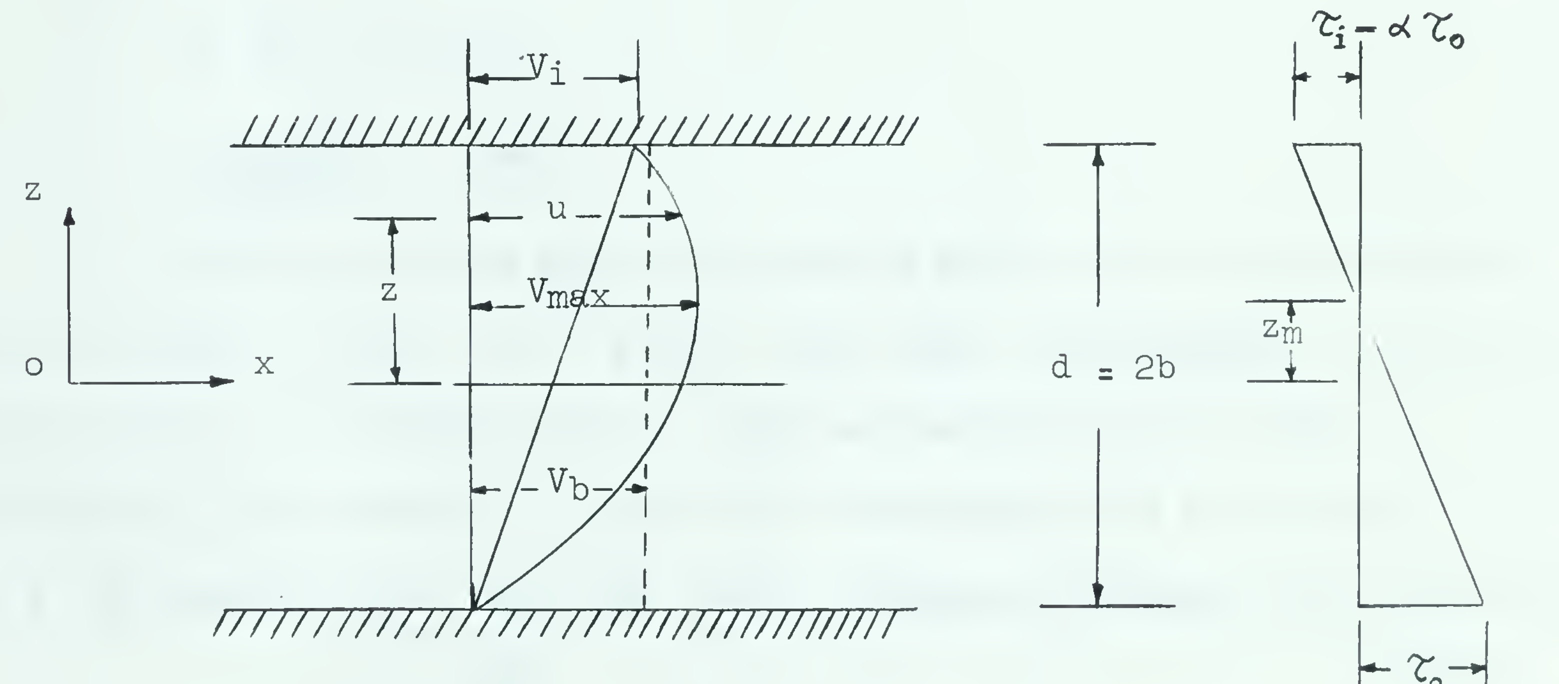
where μ_b = coefficient of viscosity of the bottom layer.

$$\tau_i = 2.64\,\mu_b \cdot \frac{V_b}{d}$$

Then he calculated the velocity at the interface V_i to be

$$V_i = 0.85\ V_b$$

Ippen and Harleman (1952) also studied uniform flow of density currents.



Velocity Diagram

Shear Stress Diagram

LAMINAR FLOW BETWEEN PARALLEL BOUNDARIES, UPPER BOUNDARY IN MOTION.

(Figure taken from Reference 4)

They start with the standard "lubrication theory" problem of a fixed and a moving plate - laminar flow. That gives

$$u = V_i\left(\frac{b+z}{2b}\right) - (z^2 - b^2)\ \frac{\rho' g\, S}{2\,\rho' \nu'} \quad \text{- - - - - - - - - - -} \quad (A)$$

In the figure, OX is supposed to be inclined below the horizon at angle S. They amend this by taking the driving force per unit volume as $\Delta\rho \cdot g \cdot S$ because the fluid of density $\rho = (\rho' - \Delta\rho)$ is assumed to replace the plate. The upper layer of density ρ is assumed to have a horizontal surface.

They also replace b by $d/2$. That gives their equation (3), which is,

$$u = V_i \left(\frac{1}{2} + \frac{z}{d}\right) - \frac{\Delta\rho}{\rho'} \frac{gS}{\nu'} d^2 \frac{1}{2} \left(\frac{z^2}{d^2} - \frac{1}{4}\right) \text{ - - - - - - (A-1)}$$

where V_b = (Mean linear velocity) + (Mean parabolic velocity

= $\frac{2}{3}$ Maximum parabolic velocity)

$$= \frac{1}{2} V_i - \frac{2}{3} \left(\frac{\Delta\rho}{\rho'} \frac{gS}{\nu'} d^2\right) \left(-\frac{1}{8}\right)$$

Divide throughout by V_b, we get

$$1 = \frac{1}{2} \frac{V_i}{V_b} + \frac{1}{12} \frac{1}{J} \text{ - (B)}$$

where $J = \dfrac{V_b^2}{(\frac{\Delta\rho}{\rho'} g) dS} \cdot \dfrac{\nu'}{V_b d}$

The overlayer has the effect of reducing gravity (as a driving force) in the ratio $\Delta\rho/\rho'$, so that $g' = g \cdot \Delta\rho/\rho$. This makes $V_b^2/(\Delta\rho/\rho') g dS$ a friction factor of a sort in a gravity field g', but as the shear stresses are different on the two "plates", it is not quite comparable with the friction factor f as used for pipes and fixed plates. Ippen and Harleman write this as,

$$J = \frac{F_b^2}{R_b S} \text{ - (B-1)}$$

where

$$F_b^2 = \frac{V_b^2}{(\frac{\Delta\rho}{\rho'} g) d}$$

$$R_b = \frac{V_b d}{\nu'}$$

But even here R_b does not have quite the significance that it has for pipes and fixed plates, since the velocity distribution is unsymmetrical. Reverting to equation (B), we have

$$\frac{V_i}{V_b} = 2 - \frac{1}{6J} \text{ - - - - - - - - - - - - - - - - - - - } (B-2)$$

So that dividing equation (A-1) by V_b , we get

$$\frac{u}{V_b} = (2 - \frac{1}{6J}) \; (\frac{1}{2} + \frac{z}{d}) - \frac{1}{2J} (\frac{z^2}{d^2} - \frac{1}{4})$$

$$= 1 + 2 \,(\frac{z}{d}) - \frac{1}{2J} \; (\frac{z^2}{d^2} + \frac{1}{3} \; \frac{z}{d} - \frac{1}{12}) \text{ - - - - - - - - - - } (B-3)$$

Ippen and Harleman then make use of Keulegan's analysis of laminar boundary layer thickness between a stationary and a moving layer of liquids of different properties; the layers being infinitely thick. Keulegan found that the answer had to depend on $\mu' \varrho' / \mu \varrho$ and that if

$$\frac{\mu' \varrho'}{\mu \varrho} = 1 \qquad\qquad V_i = 0.59 \, V_m$$

and if

$$\frac{\mu' \varrho'}{\mu \varrho} = 10 \qquad\qquad V_i = 0.35 \, V_m$$

However Ippen and Harleman limited themselves to the usual density current where 0.59 applies (if layers are infinite). Obviously they have to work out ratios like V_i/V_m, V_m/V_b which come out in terms of J alone for their simplified conditions. They have V_i/V_b already, given by equation (B-2). To get V_m/V_b, V_m is at the place where $du/d_z = 0$ (Refer fig.) i.e. differentiate (B-3) with respect to z and let $\frac{du}{d_z} = 0$

$$\text{we get } \frac{Z_m}{d} = 2J - \frac{1}{6} \text{ - - - - - - - - - - - - - - - } (B-4)$$

Putting this in (B-3), we have

$$\frac{V_m}{V_b} = \frac{2}{3} + 2\,J + \frac{1}{18J} \text{ - - - - - - - - - - - } (B-5)$$

Divide (B-2) by (B-5)

$$\frac{V_i}{V_m} = \frac{12\,J - 1}{12\,J^2 + 4J + \frac{1}{3}} \text{ - - - - - - - - - - - } (B-6)$$

Now if we use Keulegan's $V_i/V_m = 0.59$, which means assuming that the finite underlayer with maximum velocity V_m to be like Keulegan's infinite one with undisturbed velocity V, equation (B-6) gives

$$J = 0.138 \text{ - - - - - - - - - - - - (C)}$$

Ippen and Harleman further checked this value of J. In their figure obtained from experimental data, they superimpose the theoretical curve obtained from equations (B-3) and (B-5) and for $J = 0.138$. Very good agreement was found for the test conditions studied by them.

(i) Parallel stationery plates:-

For this we will have to assume $\frac{\mu}{\mu'} = \infty$

Then $V_i = 0$

Equation (B-2) gives $J = \frac{1}{12} = 0.083$

(ii) Free surface flow:-

For this $\frac{\mu}{\mu'} = 0$

Then maximum velocity occurs at half the depth

i.e. $\frac{Z_m}{d} = \frac{1}{2}$

Equation (B-4) gives $J = \frac{1}{3} = 0.333$

So a fair range of variation from $J = 0.138$ is possible in practice, that is, in liquids of considerable viscosity difference.

If we can decide on J for a case, then we have a useful formula for density currents at the bottom of a lake. For

$$J = \frac{V_b \cdot \nu'}{\frac{\Delta\rho}{\rho'} g S d^2} = \frac{q \cdot \nu'}{\frac{\Delta\rho}{\rho'} g\, S d^3}$$

$$\text{or } d^3 = \frac{1}{J} \frac{q \nu'}{\frac{\Delta\gamma}{\rho'} S} = \frac{1}{J} \cdot q \cdot \frac{\mu'}{\Delta\gamma \cdot S} \text{ - - - - - - - (D)}$$

So in a definite lake, d varies with the cube root of discharge intensity. However variation in turbidity would upset J, μ' and $\Delta\gamma$ to some extent. It must not be forgotten that this all applies to laminar flow only.

In turbulent flow one might expect to find more apparent resistance to flow than indicated by (D).

Ippen and Harleman next define a friction factor C_f in accordance with the usual engineering nomenclature. In fact $C_f = \frac{f}{4}$

Logically one may write:-

$$\tau_0 \times 1 + \tau_i \times 1 = \tau_{mean} \times 2 = \rho' g' \, dS$$

(Provided $B \gg d$)

$$\therefore \quad \frac{\tau_0 + \tau_i}{2} = \tau_{mean} = \rho' \cdot g' \cdot \frac{d}{2} \cdot S$$

$$= \frac{f}{8} \rho' V_b^2 \qquad \text{(Task Committee, 1963)}$$

For open channel flow $R_H = d$

$$f = \frac{4 g' R_H S}{V_b^2}$$

For flow between stationary parallel plates

$$R_H = d/2$$

$$\therefore f = \frac{8 g' . R_H . S}{V_b^2}$$

Ordinarily with $\tau_0 + \tau_i = \tau_0 (1 + \alpha) = \rho' g' d \, S$

so that $\tau_0 = \frac{f}{8} \rho' . V_b^2 = \rho' g' \frac{d}{1+\alpha} . S$

and $V_b = \sqrt{\frac{8}{f}} \sqrt{g' \frac{d}{1+\alpha} . S}$ - - - - - - - - - - - - - - - (E)

This makes $d/(1+\alpha)$ a kind of weighted hydraulic radius. This agrees with the other system for fixed plates and also for open channel.

With f defined, one might like to know how it is related to J and how α depends on J. To relate α to J refer to shear stress diagram on page 6 .

$$\alpha = \frac{\tau_i}{\tau_0} = \frac{1 - 2 Z_m/d}{1 + 2 Z_m/d} = \frac{\frac{1}{3} - J}{\frac{1}{6} + J} \qquad \text{- - - - - - - - - - - - (E-1)}$$

(By equation B-4)

It will be noted that α depends upon the shape of the velocity distribution curve.

Also $$f = \frac{8\,g'\,d\,S}{V_b^2\,(1+\alpha)}$$

$$= \frac{8\,S}{F_b^2\,(1+\alpha)}$$

$$= 4 \cdot C_f$$

$$= \frac{8}{J\,R_b\,(1+\alpha)} \quad \text{- - - - - - (F)} \quad \text{(By equation B-1)}$$

This is comparable with $f = \frac{64}{R_b}$ for pipes.

Ippen and Harleman found by experiment that $J = 0.138$ and $\alpha = 0.64$ nearly.

Therefore

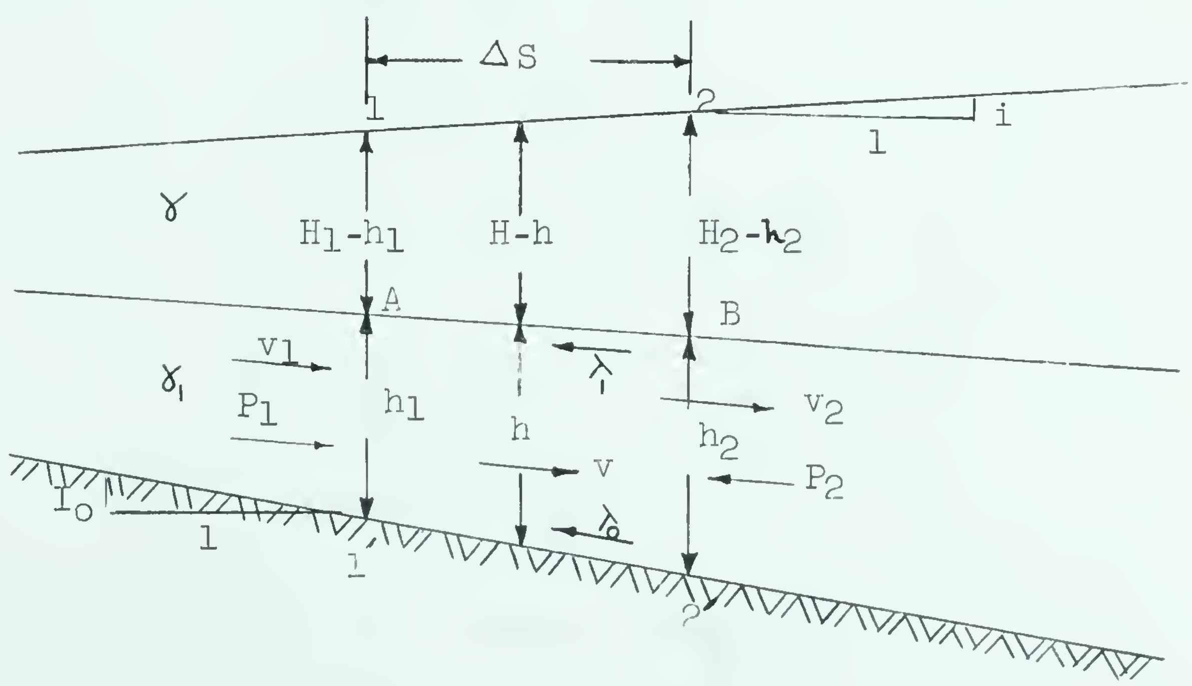
$$\frac{1}{C_f} = 0.114\,R_b \quad \text{- - - - (G)}$$

$$\text{or} \quad \frac{1}{f} = 0.0285\,R_b$$

with this, the equation (E) becomes

$$V_b = \frac{R_b^{\frac{1}{2}}}{2.7}\sqrt{\frac{\Delta\rho}{\rho'}\,g\,d\,S} \quad \text{- - (H)}$$

Levi (1959) discussed the problems of underflows in storage reservoirs. He stated that in practice the regime of underflow is either non-uniform or unsteady. He came out with the equations for non-uniform underflow case. This forms the basis of present study. The derivations of those equations are given below.



DENSITY CURRENT DIAGRAM

Consider sections 1-A-1' and 2-B-2' at ΔS apart. Consider element ΔS of unit width. Various symbols carry the following meanings:-

γ = Specific weight of the top layer.

γ_1 = Specific weight of the bottom layer.

I_o = Bed slope.

i = Surface slope.

h_1 = Thickness of density layer at section 1.

h = Thickness of density layer at middle of the strip.

h_2 = Thickness of density layer at section 2.

H_1 = Total depth of flow at section 1.

H = Total depth of flow at middle of the strip.

H_2 = Total depth of flow at section 2.

v_1 = Velocity of flow at section 1 for the density layer.

v = Corresponding velocity of flow at middle of the strip.

v_2 = Corresponding velocity of flow at section 2.

λ_o = Coefficient of friction at bed and sides.

λ_1 = Coefficient of friction at the interface.

From the figure

$$h_2 = h + \frac{dh}{dS} \cdot \frac{\Delta S}{2}$$

$$H_2 = H + I_o \frac{\Delta S}{2} + i \frac{\Delta S}{2}$$

$$H_2 - h_2 = (H - h) + \left(I_o + i - \frac{dh}{dS}\right) \frac{\Delta S}{2}$$

Similarly

$$h_1 = h - \frac{dh}{ds} \cdot \frac{\Delta S}{2}$$

$$H_1 = H - (I_o + i) \frac{\Delta S}{2}$$

$$H_1 - h_1 = (H - h) - \left(I_o + i - \frac{dh}{dS}\right) \frac{\Delta S}{2}$$

1. Equilibrium of prism 1'-A-B-2'. Resolve parallel to bed.

Different forces acting on it are:-

Pressures

$$P_1 = \gamma\left[(H - h) - (I_o + i - \frac{dh}{dS})\frac{\Delta S}{2}\right](h - \frac{dh}{dS}.\frac{\Delta S}{2})$$

$$+ \frac{\gamma_1}{2}\left(h - \frac{dh}{dS}.\frac{\Delta S}{2}\right)^2$$

and

$$P_2 = \gamma\left[(H - h) + (I_o + i - \frac{dh}{dS})\frac{\Delta S}{2}\right](h + \frac{dh}{dS}.\frac{\Delta S}{2})$$

$$+ \frac{\gamma_1}{2}\left(h + \frac{dh}{dS}.\frac{\Delta S}{2}\right)^2$$

Components of weights

$$W I_o = \gamma_1 h.\Delta S.\ I_o + \gamma(H-h)\Delta S.\frac{dh}{dS}$$

Force of friction

$$F = (\lambda_o + \lambda_1)\gamma_1 \frac{v^2}{2g}.\Delta S$$

Equation of equilibrium is

$$\Sigma F = \text{change in momentum } (M_2 - M_1) \text{ - - - - - - - - (a)}$$

But

$$M_1 = \int_o^{h_1} d(mv_1) = \int_o^{h_1} \frac{\gamma_1}{g} v_1^2 \, dy = \alpha_1 \frac{\gamma_1}{g} v_1^2 h_1$$

where $\alpha_1 = \dfrac{\int_o^{h_1} u^2 dy}{v_1^2 h_1}$ $\qquad u = $ local velocity

Similarly

$$M_2 = \alpha_1 \frac{\gamma_1}{g} v_2^2 h_2$$

(Assuming $\alpha_2 = \alpha_1$)

$$M_2 - M_1 = \alpha_1 \frac{\gamma_1}{g} h v (v_2 - v_1)$$

$(\because h_1 v_1 = h v = h_2 v_2)$

$$= \alpha_1 \frac{\gamma_1}{g} hv.dv$$

$$= \alpha_1 \gamma_1 h \frac{d}{dS}\left(\frac{v^2}{2g}\right)\Delta S$$

By equation (a)

$$P_1 - P_2 + WI_o - F = M_2 - M_1$$

$$\text{or} \quad P_1 - P_2 + WI_o = F + (M_2 - M_1)$$

substituting values from above

$$\gamma(H-h)h - \gamma h\left(I_o + i - \frac{dh}{ds}\right)\frac{\Delta S}{2} - \gamma(H-h)\frac{dh}{ds}\cdot\frac{\Delta S}{2}$$

$$+\gamma\left(I_o + i - \frac{dh}{ds}\right)\frac{dh}{ds}\left(\frac{\Delta S}{2}\right)^2 + \frac{\gamma_1}{2}\left[h^2 - 2h\frac{dh}{ds}\cdot\frac{\Delta S}{2} + \left(\frac{dh}{ds}\cdot\frac{\Delta S}{2}\right)^2\right]$$

$$-\gamma(H-h)h - \gamma h\left(I_o + i - \frac{dh}{ds}\right)\frac{\Delta S}{2} - \gamma(H-h)\frac{dh}{ds}\frac{\Delta S}{2}$$

$$-\gamma\left(I_o + i - \frac{dh}{ds}\right)\frac{dh}{ds}\left(\frac{\Delta S}{2}\right)^2 - \frac{\gamma_1}{2}\left[h^2 + 2h\frac{dh}{ds}\cdot\frac{\Delta S}{2} + \left(\frac{dh}{ds}\cdot\frac{\Delta S}{2}\right)^2\right]$$

$$+\gamma_1 h\Delta S I_o + \gamma(H-h)\Delta S\frac{dh}{ds} = (\lambda_o + \lambda_1)\gamma_1\frac{v^2}{2g}\Delta S + \alpha_1\gamma_1 h\frac{d}{ds}\left(\frac{v^2}{2g}\right)\Delta S$$

$$\text{or} \quad -\gamma h\left(I_o + i - \frac{dh}{ds}\right)\Delta S - \gamma_1 h\frac{dh}{ds}\Delta S + \gamma_1 h\Delta S . I_o$$

$$= (\lambda_o + \lambda_1)\gamma_1\frac{v^2\Delta S}{2g} + \alpha_1\gamma_1 h\frac{d}{ds}\left(\frac{v^2}{g}\right)\Delta S$$

Divide throughout by $(h . \Delta S)$

$$-\gamma\left(I_o + i - \frac{dh}{ds}\right) - \gamma_1\frac{dh}{ds} + \gamma_1 I_o$$

$$= (\lambda_o + \lambda_1)\gamma_1\frac{v^2}{2gh} + \alpha_1\gamma_1\frac{d}{ds}\left(\frac{v^2}{2g}\right)$$

$$\text{or} \quad (\gamma_1 - \gamma)\left(I_o - \frac{dh}{ds}\right) = (\lambda_o + \lambda_1)\gamma_1\frac{v^2}{2gh} + \gamma i + \alpha_1\gamma_1\frac{d}{ds}\left(\frac{v^2}{2g}\right) \quad - - - - (1)$$

2. Equilibrium of prism 1-1'-2'-1

Different forces acting on it are

Pressures

$$P_1 = \frac{\gamma}{2}\left[H - (I_o + i)\frac{\Delta S}{2}\right]^2 + \frac{\gamma_1 - \gamma}{2}\left(h - \frac{dh}{ds}\frac{\Delta S}{2}\right)^2$$

$$= \frac{\gamma}{2}\left[H^2 - 2H(I_o + i)\frac{\Delta S}{2} + (I_o + i)\frac{\Delta S^2}{4}\right]$$

$$+\frac{\gamma_1 - \gamma}{2}\left[h^2 - 2h\frac{dh}{ds}\frac{\Delta S}{2} + \left(\frac{dh}{ds}\cdot\frac{\Delta S}{2}\right)^2\right]$$

and $$P_2 = \frac{\gamma}{2}\left[H + (I_o + i)\frac{\Delta S}{2}\right]^2 + \frac{\gamma_1-\gamma}{2}\left(h + \frac{dh}{ds}\,\frac{\Delta S}{2}\right)^2$$

$$= \frac{\gamma}{2}\left[H^2 + 2H(I_o + i)\frac{\Delta S}{2} + (I_o + i)^2\frac{\Delta S^2}{4}\right]$$

$$+ \frac{\gamma_1-\gamma}{2}\left[h^2 + 2h\frac{dh}{ds}\cdot\frac{\Delta S}{2} + \left(\frac{dh}{ds}\cdot\frac{\Delta S}{2}\right)^2\right]$$

Components of weight

$$W = \gamma H.\Delta S.\ I_o + (\gamma_1-\gamma)\ h.\Delta S.I_o$$

Force of friction

$$F = \lambda_o\ \gamma_1 \cdot \frac{v^2}{2g} \cdot \Delta S$$

Equation of equilibrium is

$$\Sigma F = \text{Change in momentum } (M_2 - M_1) \text{ - - - - - - - - - - (b)}$$

Assuming that velocity in the top layer is negligible,

change in momentum $= M_2 - M_1 = \alpha_1 \gamma_1 h \frac{d}{ds}\left(\frac{v^2}{2g}\right) . \Delta S$

By equation (b) (As in the first case)

$$P_1 - P_2 + W = F + M_2 - M_1$$

Substituting values from above

$$\frac{\gamma}{2}H^2 - \gamma H(I_o + i)\frac{\Delta S}{2} + \frac{\gamma}{2}(I_o + i)^2\frac{\Delta S^2}{4} + \frac{\gamma_1-\gamma}{2}h^2 - (\gamma_1-\gamma)h\frac{dh}{ds}.\frac{\Delta S}{2}$$

$$+ \frac{\gamma_1-\gamma}{2}\left(\frac{dh}{ds}.\frac{\Delta S}{2}\right)^2$$

$$-\frac{\gamma}{2}H^2 - \gamma H(I_o + i)\frac{\Delta S}{2} - \frac{\gamma}{2}(I_o + i)^2\frac{\Delta S^2}{4} - \frac{\gamma_1-\gamma}{2}h^2 - (\gamma_1-\gamma)h\frac{dh}{ds}.\frac{\Delta S}{2}$$

$$-\frac{\gamma_1-\gamma}{2}\left(\frac{dh}{ds}.\frac{\Delta S}{2}\right)^2 + \gamma H\Delta S.I_o + (\gamma_1-\gamma)\ h.\Delta S.\ I_o$$

$$= \lambda_o\ \gamma_1\ \frac{v^2}{2g}.\Delta S + \alpha_1\gamma_1 h\frac{d}{ds}\left(\frac{v^2}{2g}\right).\Delta S$$

or $$-\gamma H i.\Delta S - (\gamma_1-\gamma)\ h.\frac{dh}{ds}\Delta S + (\gamma_1-\gamma)\ h.\Delta S.\ I_o$$

$$= \lambda_o.\gamma_1.\frac{v^2}{2g}.\Delta S + \alpha_1\gamma_1 h\frac{d}{ds}\left(\frac{v^2}{2g}\right)\Delta S$$

Divide throughout by $(h.\Delta S)$

$$(\gamma_1 - \gamma)\left(I_o - \frac{dh}{ds}\right) = \lambda_o \cdot \gamma_1 \frac{v^2}{2gh} + \gamma \frac{H}{h} \cdot i + \alpha_1 \gamma_1 \frac{d}{ds}\left(\frac{v^2}{2g}\right) \quad \text{- - - (2)}$$

3. Subtract (2) from (1),

$$\gamma i = \gamma_1 \lambda_1 \frac{v^2}{2g(H-h)} \quad \text{- - - - - - - - - - - - - (3)}$$

which gives

$$\frac{h}{H} = 1 - \frac{\gamma_1}{\gamma} \frac{\lambda_1}{i} \frac{v^2}{2gH}$$

$$= 1 - \frac{\rho + \Delta\rho}{\rho} \cdot \frac{\lambda_1}{i} \cdot \frac{v^2}{2gh} \cdot \frac{h}{H}$$

or
$$\frac{h}{H} = \frac{1}{1 + \frac{\rho+\Delta\rho}{\rho} \cdot \frac{\lambda_1}{i} \cdot \frac{F_b^2}{2}} \quad \text{- - - - - - - - - - - - (4)}$$

where $F_b = \frac{v}{\sqrt{gh}}$ = Froude's number of the density layer.

$$\gamma_1 = (\rho + \Delta\rho) g$$

$$\gamma = \rho g$$

where $(\rho+\Delta\rho)$ and ρ are densities of the bottom and top layers respectively.

$\frac{h}{H}$ is the non dimensional thickness of the density layer.

4. From equations (1) and (3)

$$\frac{\gamma_1 - \gamma}{\gamma_1}\left(I_o - \frac{dh}{ds}\right) = \left(\lambda_o + \lambda_1 \frac{H}{H-h}\right)\frac{v^2}{2gh} + \alpha_1 \frac{d}{ds}\left(\frac{v^2}{2g}\right)$$

In a rectangular flume

$$v = q/h$$

by rearranging

$$\frac{dh}{ds} = \frac{\frac{\gamma_1 - \gamma}{\gamma_1} I_o - \left(\lambda_o + \lambda_1 \frac{H}{H-h}\right)\frac{q^2}{2gh^3}}{\frac{\gamma_1-\gamma}{\gamma_1} - \frac{\alpha_1 q^2}{g h^3}} \quad \text{- - - - - - - - - - - - - (5)}$$

$$= \frac{\frac{\Delta\rho}{\rho+\Delta\rho} I_o - \lambda \frac{Fb^2}{2}}{\frac{\Delta\rho}{\rho+\Delta\rho} - \alpha_1 Fb^2} \quad \text{------------------------------} \quad (5\text{-a})$$

To get critical depth, h_c

$$\frac{\gamma_1 - \gamma}{\gamma_1} - \frac{\alpha_1 q^2}{g\, h^3} = 0$$

$$\text{or} \quad h = h_c = \sqrt[3]{\frac{\alpha_1 q^2}{g \frac{\Delta\rho}{\rho+\Delta\rho}}} = \sqrt[3]{\frac{\alpha_1 q^2}{g'}} \quad \text{----------------} \quad (6)$$

where $g' = g \cdot \dfrac{\Delta\rho}{\rho + \Delta\rho}$

and critical velocity $v_c = \dfrac{q}{h_c}$

$$= \sqrt[3]{\frac{g' q}{\alpha_1}}$$

$$= \sqrt[3]{g' q} \quad \text{------------------------} \quad (7)$$

(taking $\alpha = 1$)

Levi then goes on to compute the minimum specific weight (γ min) of the density layer for which the flow would be stable. This was later on used to work out the minimum density needed for the density currents to form at specific values of q, D, I_o and λ.

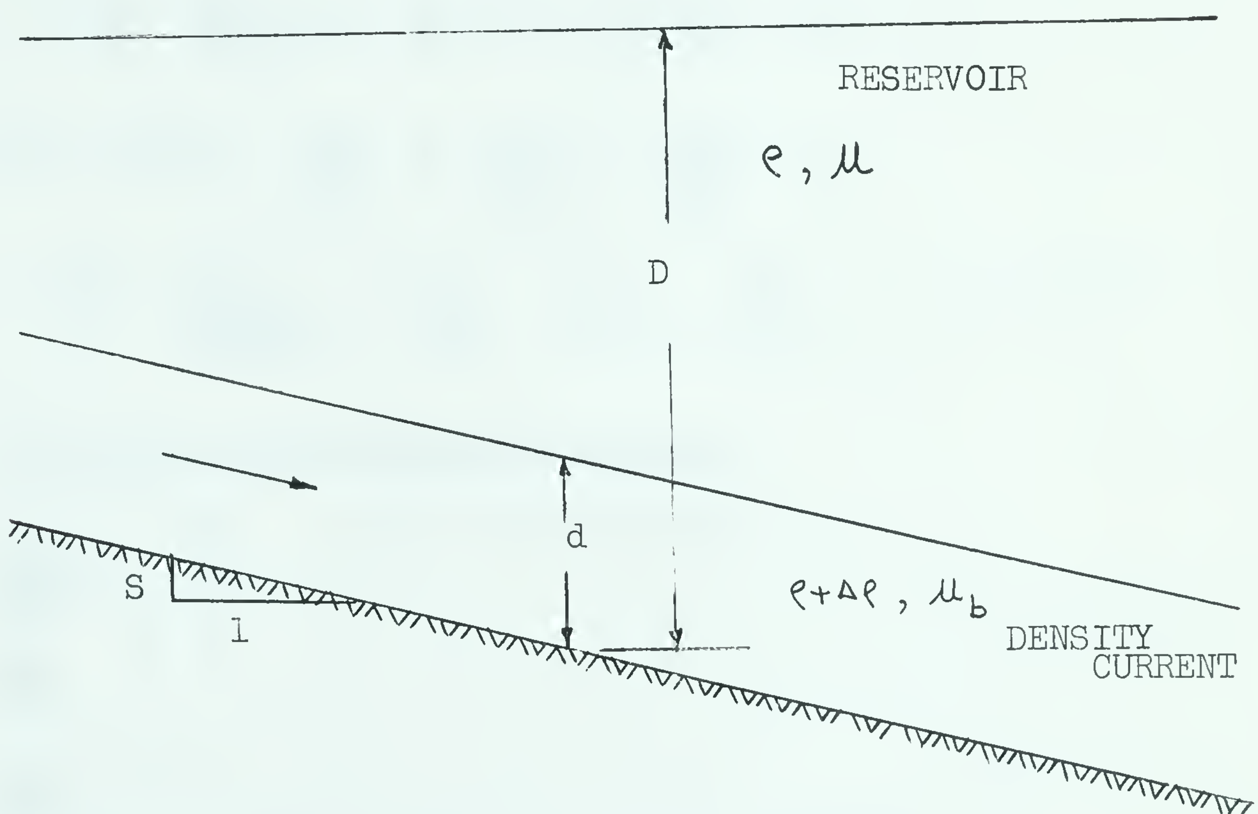
CHAPTER III

3.0 DIMENSIONAL ANALYSIS

Dimensional analysis is carried out to provide a basis for the analysis of experimental data.

3.1 Non dimensional thickness of density layer

Consider a steady state case of Ippen and Harleman (Refer Chapter II) but with large μ and ρ differences. We shall assume that the reservoir depth D has some relevance.



SKETCH SHOWING MOVEMENT OF DENSITY CURRENTS

In a reservoir of uniform breadth B, a density current of properties μ_b, $\rho+\Delta\rho$ and discharge Q is imposed and allowed to acquire steadiness. The bed slope is S and the superincumbent fluid has properties μ and ρ. The depth of reservoir is D. The flow is determined and d is related to the quoted variables, so that:

$$fn\ (d,\ Q,\ gS,\ \mu,\ \mu_b,\ \rho,\ \rho+\Delta\rho\ ,\ B,\ D) = 0$$

g by itself has been left out as the suspension is nearly colloidal and so will not tend to settle under operating conditions. We can replace Q by V_b,

since $Q = fn\,(V_b, B, d)$

Doing so and remembering the preceeding analysis, we elect to arrange variables as below:

$$fn\left(\frac{V_b d}{\mu_b/(\rho+\Delta\rho)}, \frac{V_b^2}{g d_S}, \frac{\mu}{\mu_b}, \frac{\rho}{\rho+\Delta\rho}, \frac{V_b D}{\mu_b/(\rho+\Delta\rho)}, \frac{B}{D}\right) \text{ - - - - - } (3.1 - 1)$$

or

$$fn\left(\frac{V_b d}{\nu_b}, \frac{V_b^2}{g d_S} \times \frac{\nu_b}{V_b d}, \frac{\mu}{\mu_b}, \frac{\rho}{\rho+\Delta\rho}, \frac{V_b d}{\nu_b}, \frac{B}{D}\right) = 0$$

We can replace $\frac{\rho}{\rho+\Delta\rho}$ by $1 - \frac{\rho}{\rho+\Delta\rho} = \frac{\Delta\rho}{\rho+\Delta\rho}$

Doing so, we can write (to suit previous analysis)

$$fn\left(\frac{V_b d}{\nu_b}, \frac{V_b^2}{\frac{\Delta\rho}{\rho+\Delta\rho} d_S} \frac{\nu_b}{V_b d}, \frac{\mu}{\mu_b}, \frac{\Delta\rho}{\rho+\Delta\rho}, \frac{V\,D}{\nu_b}, \frac{B}{D}\right) = 0 \text{ - - - - - } (3.1 - 2)$$

We can further replace $\frac{V_b d}{\nu_b}$ by $\frac{V_b d}{\nu_b} \times \frac{\nu_b}{V_b D} = \frac{d}{D}$

Hence

$$fn\left(\frac{V_b d}{\nu_b}, \frac{V_b^2}{\frac{\Delta\rho}{\rho+\Delta\rho} g d_S} \cdot \frac{\nu_b}{V_b d}, \frac{\mu}{\mu_b}, \frac{\Delta\rho}{\rho+\Delta\rho}, \frac{d}{D}, \frac{B}{D}\right) = 0 \text{ - - - } (3.1 - 3)$$

3.2 Applications of dimensional analysis

$\frac{V_b^2}{\frac{\Delta\rho}{\rho+\Delta\rho} g d_S} \frac{\nu_b}{V_b d}$ is Ippen and Harleman's J.

$\frac{V_b d}{\nu_b}$ is R_b

$\frac{V_b . D}{\nu_b}$ is R

Therefore equation (3.1 - 2) is written as

$$fn\left(R_b, J, \frac{\mu}{\mu_b}, \frac{\Delta\rho}{\rho+\Delta\rho}, R, \frac{B}{D}\right) = 0 \text{ - - - - - - - - - - - - - - - - } (3.2 - 1)$$

Physically it appears unlikely that R is significant if $D \gg d$, similarly $\frac{B}{D}$ is not likely to be significant if $B \gg D$.

Therefore $fn\left(R_b, J, \frac{\mu}{\mu_b}, \frac{\Delta\rho}{\rho+\Delta\rho}\right) = 0$ - - - - - - - - - - - - - - - - - - (3.2 - 2)

can be expected to represent the phenomenon.

Keulegan (1944) showed that $\frac{\mu_b}{\mu}$ and $\frac{\rho+\Delta\rho}{\rho}$ can be combined into

one term $\mu_b(\rho+\Delta\rho)/\mu\rho$ for a special case and laminar flow. Using this criterion, equation (3.2 - 2) becomes

$$fn\left(R_b,\ J,\ \frac{\mu_b(\rho+\Delta\rho)}{\mu\rho}\right) \text{ - } (3.2 - 3)$$

This should hold so long as a definite interface exists.

Equation (3.2 - 3) suggests a special form involving $\mu_b(\rho+\Delta\rho)/\mu\rho$, which might apply for non-laminar flow.

There are many alternatives. However, for the present, the following will be considered. In (3.1 - 3), replace

$$\frac{V_b^2}{\frac{\Delta\rho}{\rho+\Delta\rho} g\, d_S}\ \frac{\nu_b}{V_b\, d} \quad \text{by} \quad \frac{V_b^2}{\frac{\Delta\rho}{\rho+\Delta\rho} g\, d_S}$$

we have

$$fn\left(\frac{V_b d}{\nu_b},\ \frac{V_b^2}{\frac{\Delta\rho}{\rho+\Delta\rho} g\, d_S},\ \frac{\mu}{\mu_b},\ \frac{\Delta\rho}{\rho+\Delta\rho},\ \frac{d}{D},\ \frac{B}{D}\right) = 0$$

Now $\frac{V_b^2}{\frac{\Delta\rho}{\rho+\Delta\rho} g\, d_S}$ is a sort of a friction factor λ,

so replace $\frac{V_b^2}{\frac{\Delta\rho}{\rho+\Delta\rho} g\, d_S}$ by λ

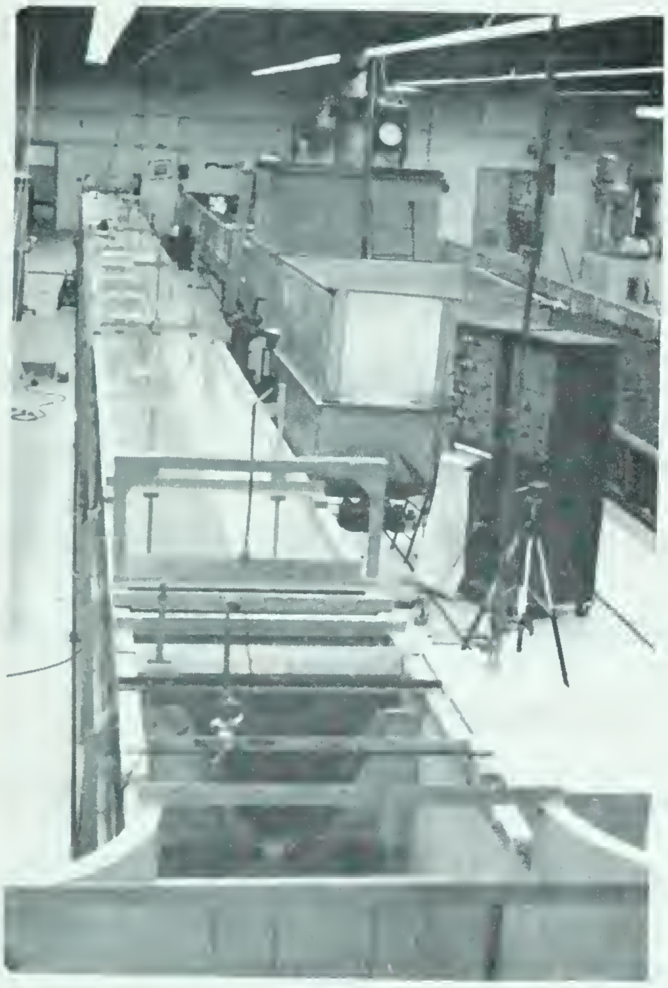
and omit $\frac{B}{D}$ as argued previously. Then applying Keulegan's criterion, the above function reduces to

$$fn\left(R_b,\ \lambda,\ \frac{\mu_b(\rho+\Delta\rho)}{\mu\rho},\ \frac{d}{D}\right) = 0$$

$$\text{or} \quad \frac{d}{D} = fn\left(R_b,\ \lambda,\ \frac{\mu_b(\rho+\Delta\rho)}{\mu\rho}\right)$$

This suggests that λ depends on R_b, $\mu_b(\rho+\Delta\rho)/\mu\rho$ and $d/_D$. Similarly it looks that $d/_D$ might depend on λ, R_b and $\mu_b(\rho+\Delta\rho)/\mu\rho$. So one might plot λ against R_b for different values of $d/_D$, if the effect of $\mu_b(\rho+\Delta\rho)/\mu\rho$ is neglected. The variation in $\mu_b(\rho+\Delta\rho)/\mu\rho$ has been from 1.006 to 1.560. It must not be forgotten that this analysis depends on the interface being definite and not a transition layer.

Photograph No. 1

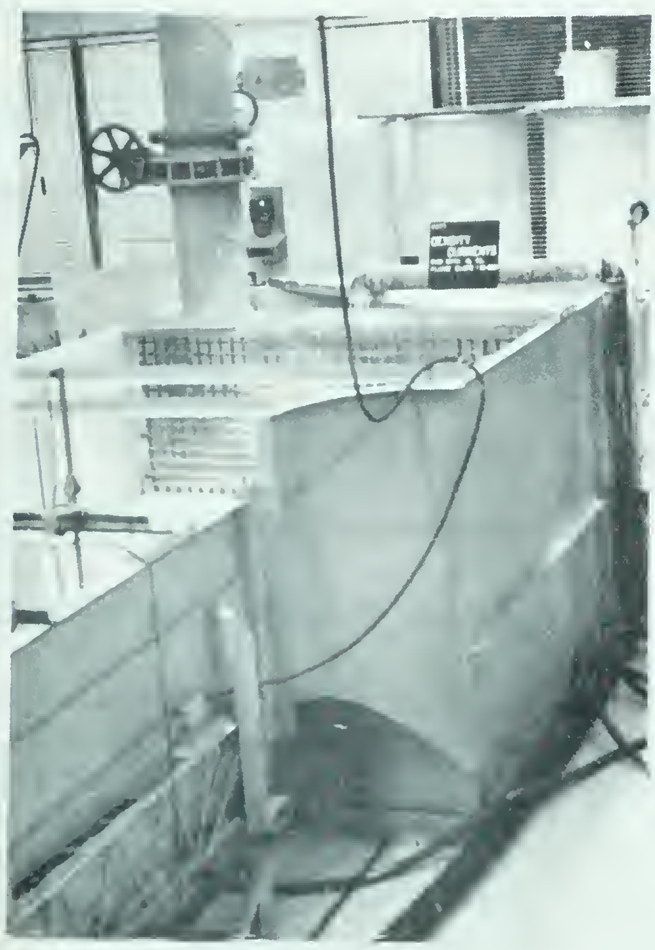


Overall view of flume as seen from top, showing Sanborn equipment, weir plate, etc.

Photograph No. 2

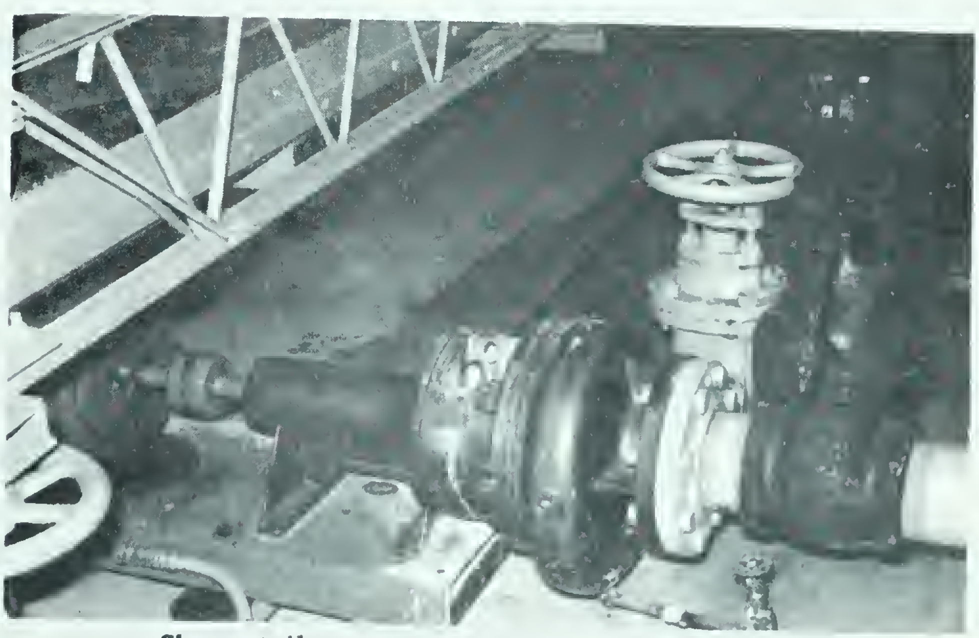
Overall view of flume as seen from tail end.

Photograph No. 3



Shows 12 inch delivery pipe, polythene tanks, head tank, coarse and fine screens, etc.

Photograph No. 4



Shows tail pump coupled with a motor, inlet and outlet valve.

CHAPTER IV

4. Experimental Layout and Working Techniques

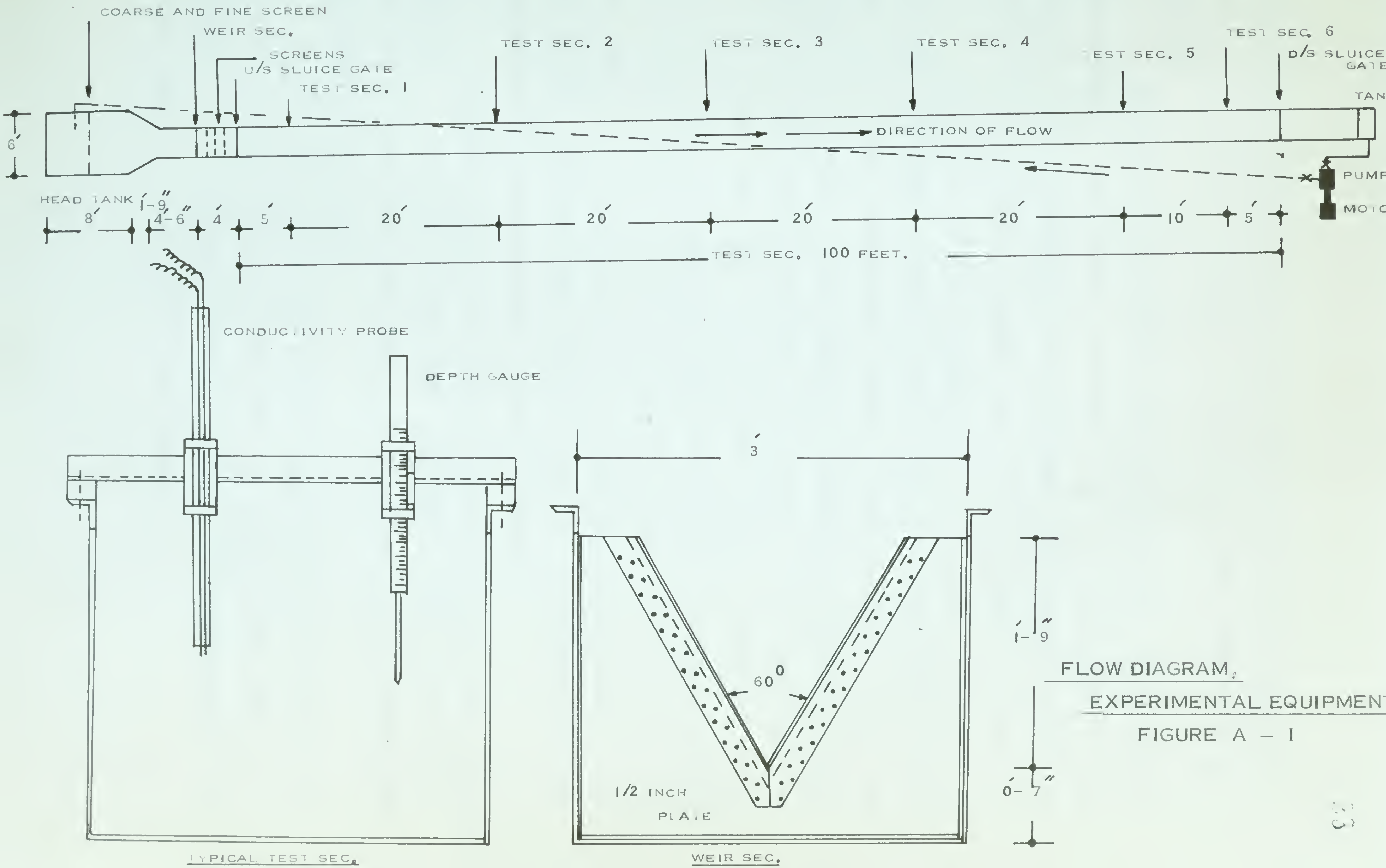
4.1 General Description

The experiments were conducted in a straight tilting rectangular flume 120 feet long, 3 feet wide, and 3 feet deep as shown in the flow diagram. Water could be pumped in the head tank through a 12 inch diameter delivery pipe by a pump coupled with an A.C. 15 h.p. motor. At the back of the head tank, a platform was raised for accommodating three polythene tanks in which salt or aluminium silicate solutions were made well ahead of time.

In order to dampen out turbulence in the head tank, a coarse screen made out of half-inch diameter bars, placed at two-inch centre both ways was installed in the flume at $2\frac{1}{2}$ feet from the 4 inch delivery pipe. Over this a fibreglass screen of 18 x 14 mesh was placed. One more fibreglass window screen was installed 4 feet above the weir. Three fibreglass window screens, out of which one was combined with a coarse screen made out of three-quarter inch round bars at two-inch centre vertically, were placed between the weir and the upstream sluice gate at one-foot intervals. These were desired to smoothen the flow before it dipped down the sluice gate.

To measure the flow, a V-shaped weir was installed $4\frac{1}{2}$ feet from the head of the flume. This was calibrated before the tests (Refer Appendix A). For the flow to dip down the clear water headed in a flume, a sluice gate was provided 5 feet below the weir. This could be adjusted to any height by a handle provided at the top. A similar gate was provided at 104 feet downstream of the weir to cut off the effects of the outlet. These gates were installed in the flume by bevelled aluminium metal strips at the sides which were screwed to the walls of the flume.

To enable the test to run for a couple of days a recirculatory system was planned. For this a small tank 3 feet wide, $1\frac{1}{4}$ feet deep, and 3 3/4 feet high, open at one side, was attached to the tail end of the flume. A



FLOW DIAGRAM.

EXPERIMENTAL EQUIPMENT.

FIGURE A – I

four-inch suction from one side of this tank lead into a pump coupled with an A.C. 5 h.p. motor. This had a four-inch delivery pipe leading into the head tank.

To take observations, 6 test sections were selected. Their distances were so adjusted that sections 2 to 5 fell in the 4 windows available. This was done to see and photograph the flow patterns, the advance of density currents and the interfacial mixing. These were located as shown in Figure A-1.

Each test section was equipped with a point gauge for recording the total depth, thickness of density layer and depth for making velocity measurements; and a second gauge to which either a conductivity probe or syphon could be fixed. At section 3, a third gauge for accommodating a probe for current meter and a dummy probe was attached, but since the velocities were very low, of the order of about an inch per second, the current meter did not work, so at the first run for the first three observations, no velocity measurements were recorded. Then to measure the velocity, two dyes of different densities were prepared. One of these was used in the top layer and the second in the density layer. These dyes were injected in the flow at different depths and observations for the calculations of velocity were made.

To measure salinity at different test sections on the flume, oscillograph recorder was set up on one side of the flume. Wiring was done along the flume to connect the conductivity probe at each section to its corresponding circuit in the recorder.

For runs with aluminium silicate, samples were drawn from different depths and hydrometer analysis carried out. To study the effect of the rate of withdrawal, the suction head was reduced by raising the sample bottles. This made no change with the specific gravity readings.

4.2 Setting up for Tests

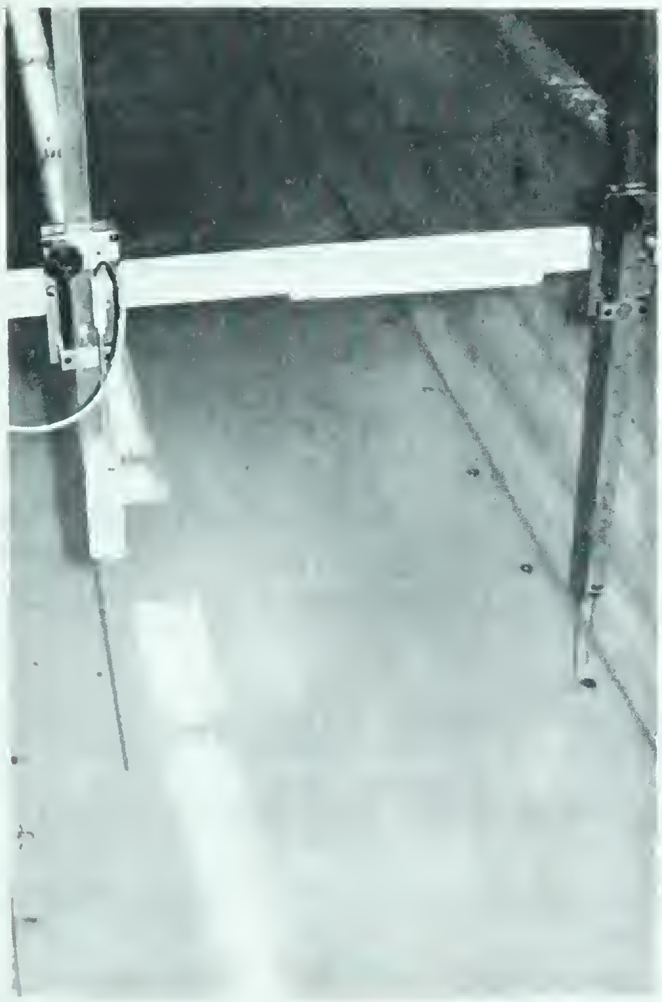
For each test run, clear water was headed in the flume to a certain height and the sluice gates were set at a predetermined level. Water in the head tank was either saline or muddy. The weir opening was blocked with a clamped plank and a rubber packing.

For runs with salt, the recorder was switched on and all the 6 channels were put into action about 1-1/2 hours before the test. Of this about 30 minutes were needed for the machine to warm up and next one hour for balancing the circuits and setting required ranges. Then bed and surface were read by point gauges and conductivity probes/syphons.

Then additional water, either saline or muddy, was added from the polythene tanks into the head tank and the block over the weir opening removed and the valve on the suction side of the pump was opened and the motor started. Then the valve on the delivery side was opened very slowly so that some head over the weir was built up. Special care was taken so that the discharge was not excessive and mixing did not take place soon.

Readings of depth, salinity, or turbidity and velocity measurements were made at regular intervals of time until the layer approached the surface. Then the test was stopped and the water run out of the flume. In the case of tests with clay, readings of the bed were taken about 24 hours after the closure of the test to have an idea of the deposits on the bed. After the second run with clay, to supplement the data of deposits on the bed, 2 inches by 3 inches plates cut out of metal sheet of gauge 10/1000 inch were laid in the flume at sections 2, 4, and 6 before the commencement of the test, at some intervals later on and at the end of the test. These were withdrawn 24 hours after the end of the test when the flume was drained out.

Photograph No. 5



A typical test section showing a Conductivity Probe and a depth gauge.

Photograph No. 6

A typical test section showing a syphon leading into sample bottles and a depth gauge.

Photograph No. 7

Shows the probe at section 4 being set in a predetermined range of salinity concentration.

Photograph No. 8

Shows the reduced suction head for a syphon.

For measurements of salinity or for drawing samples for hydrometer analysis, about four depths were selected at each section, one near the bed, second below the interface, third above the interface, and fourth near the top surface.

Every time the test was changed from salt to clay or vice versa, the tank and flume was thoroughly flushed with clear water from the main pump coupled with a motor.

4.3 Changing Slope of Flume.

When four tests were run with a level flume, the slope was to be changed. For this a tilting level was fixed near the head of the flume as close as possible and the level tube given the same slope as was required of the flume. Then the wheels at the base of the flume on both sides were turned clockwise gradually, starting from the tail end, with two turns and then the remaining with 1 2/3, 1 1/3, 1, 2/3, and 1/3 turns respectively. This procedure was repeated until the desired slope was obtained. To ensure this, the slope was checked at all the intermediate points above the wheels. Then the cross levels were also checked. Only two slopes were tried. Those were 1 in 360 and 1 in 180. Each time two tests were run, one each with clay and salt.

CHAPTER V

5. Collection of Flume Data

In order to describe the flow profile of density currents, data regarding the total depth of water in the flume, thickness of density layer, head over the weir, time from the start of the test, velocity profiles in the top and bottom layers, salinity or aluminium silicate concentrations at various depths in the flume, and of water discharging over the weir was collected for various test runs. However, in the case of test run No. 1, for the first three sets of observations, no velocity measurements could be done. An attempt was being made to work with the current meter which would not record very low velocities. For all subsequent velocity measurements, dyes prepared from kerosene oil, ethylene chloride and a blue pigment were injected and droplets of these were followed.

In all, eight runs were made, out of which four were made with level flume, two with flume sloping 1 in 360 and the remaining two with a flume slope of 1 in 180. A brief description of the tests is given below:

Test Run No. 1.

This was run with salt. Fluorescene dye was added in the head tank to observe the flow of density currents. To measure salinity of water, probes were set in the range of 0 to 1% salinity by weight. The upstream and downstream sluice gates were fixed at 3 inches above the bed of the flume. Readings were taken at 1, 2, 3, 4, 5, 7, 8, 9, 10, and 11 hours after the start of the test. The test was discontinued after 24 hours when the density layer had reached near the top surface.

Test Run No. 2.

This was again run with salt. Probes were set in the range 0 to 1% salinity by weight. Upstream and downstream, gates were set at 4 inches

above the bed. Readings were taken at 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, and 11 hours after the start of the test. The test was run for 24 hours when the density layer had reached the top surface.

Test Run No. 3.

This was the first test made with aluminium silicate. Now, instead of the conductivity probes, syphons were fixed at the test sections. Sluice gates were set at 5 inches above the bed. Readings were taken at intervals shown on the data sheets. The test was stopped after 92 hours of running. The density layer had not yet reached the top. After the flume was drained out, the deposits at the bed were noted, and when they had dried the gauge readings were recorded.

Test Run No. 4.

This test was run with aluminium silicate with the sluice gates set at 4 inches above the bed. The readings were recorded as shown on the data sheets. The test was discontinued after 72 hours of running and the flume drained out. Readings of the deposits were taken as in Test No. 3.

Test Run No. 5.

This was the first test run with aluminium silicate on a flume sloping 1 in 360. Sluice gates were set at 5 inches above the bed. The observations were recorded at intervals. The test was stopped after 72 hours. The water in the flume was drained out and the reading of the deposits were recorded.

To study the rate of deposits at the bed, 2 inches by 3 inches strips cut out of 10/1000 inch gauge metal were laid at sections 2, 4, and 6 before the commencement of the test and at the intervals indicated in the table showing the

measurements of deposits at the bed of the flume. The last set was placed at the end of the test before the flume was drained out to know the deposits during the clearing out process.

Test Run No. 6.

This run was made with salt on a flume sloping 1 in 360 with the sluice gates set at 5 inches above the bed. Probes were set between 0 and 2% salinity range. The test was continued for 25 hours, when the layer was nearly mixed up and the test stopped.

Test Run No. 7.

This test was made with salt on a flume sloping 1 in 180 with the gates set at 5 inches above the bed. Probes were set between 0 and 2% salinity range. The test was continued for 25 hours. Then the density layer had reached near the top surface and the test was stopped.

Test Run No. 8.

This was the last run on a flume slope of 1 in 180 with the gates set at 5 inches above the bed. This test was run with aluminium silicate. The test was continued for 25 hours.

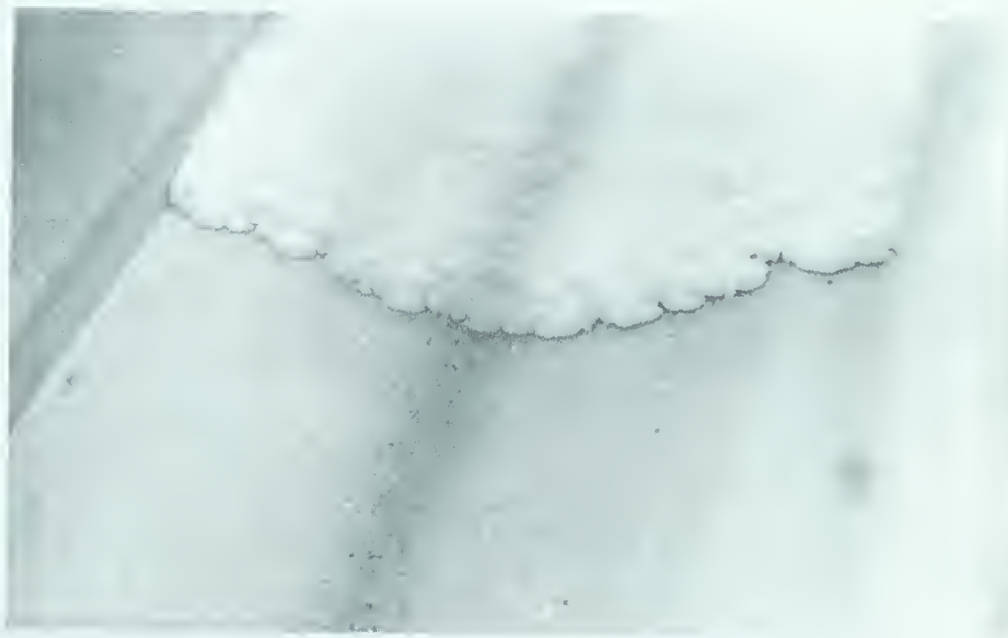
The data collected from the above tests has been placed in Appendix 5. Readings of depth, etc., appear in P-tables. Velocity measurements are set in V-tables. Observations of salt and aluminium silicate are placed in S and AS tables respectively.

Photograph No. 9

Density layer front approaching test section 3 for Test Run 4

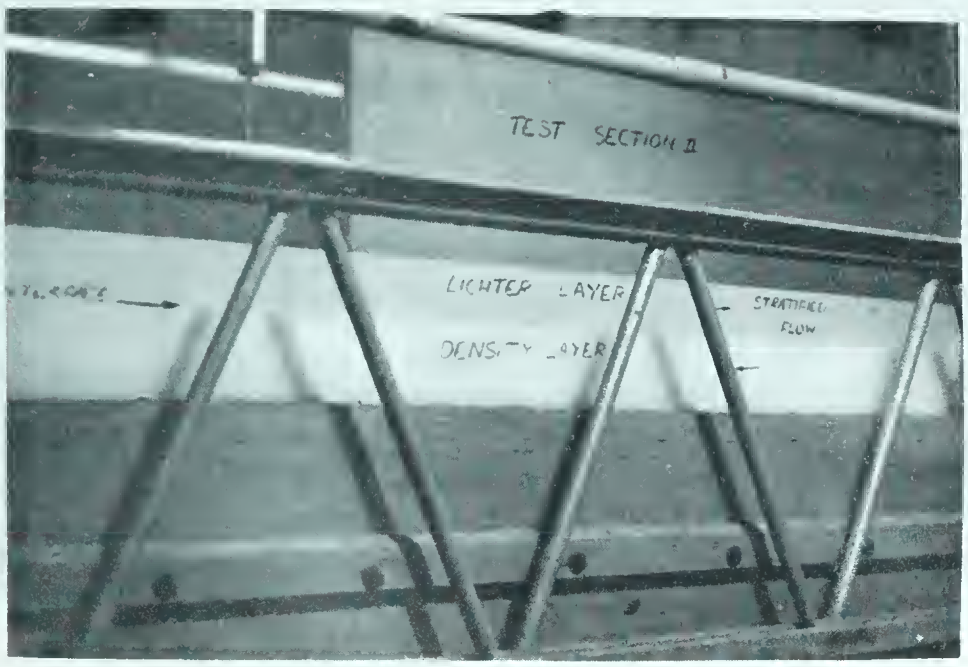
Photograph No. 10

Density currents between test sections 3 and 4 for Test Run 4.



Photograph No. 11

Shows deposits at bed after Test Run 4, near section 6.

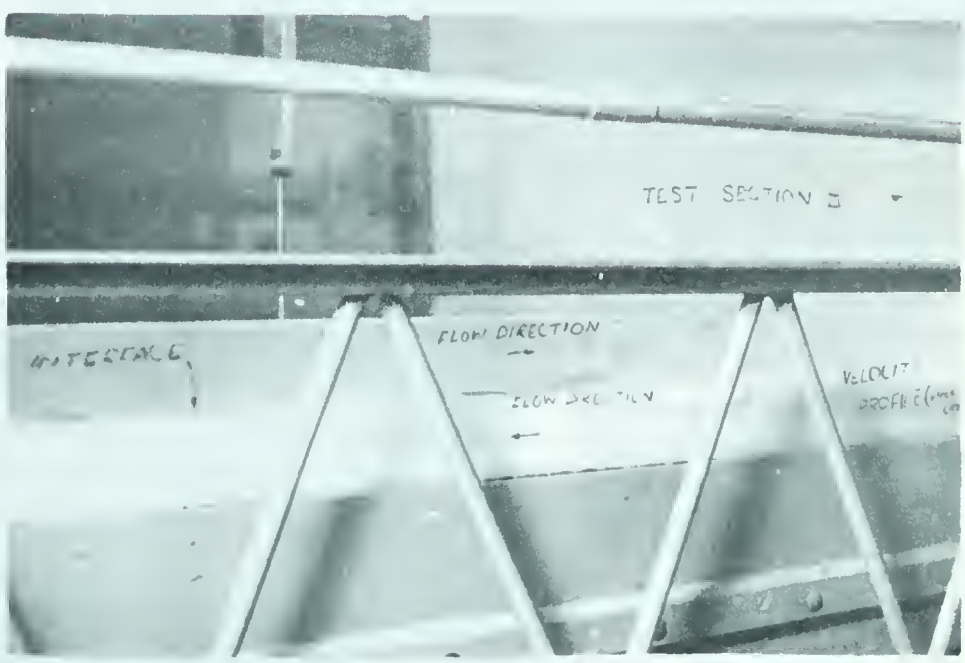


Photograph No. 12

Shows two layered flow. Interface was very well defined. This was taken during Test Run 2.

Photograph No. 13

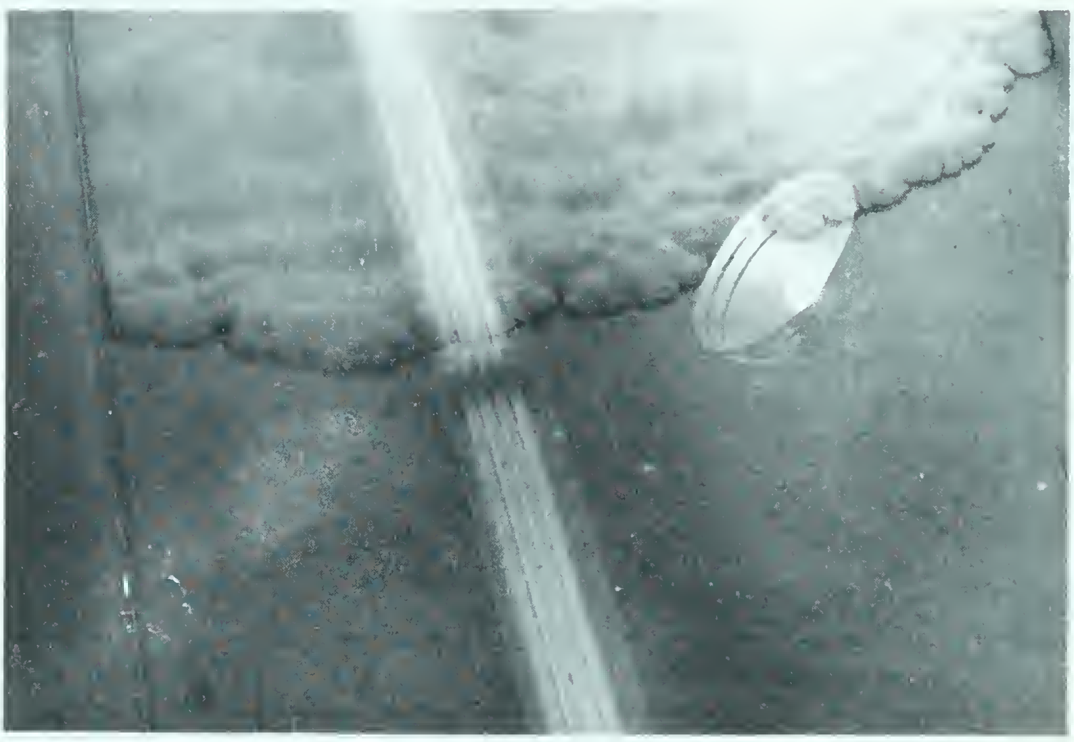
Flow in two layers is shown by arrows. Dye injected in top layer shows flow upstream.



PHOTOGRAPHS FOR TESTRUN 5

Photograph No. 14

Density currents near section 2.

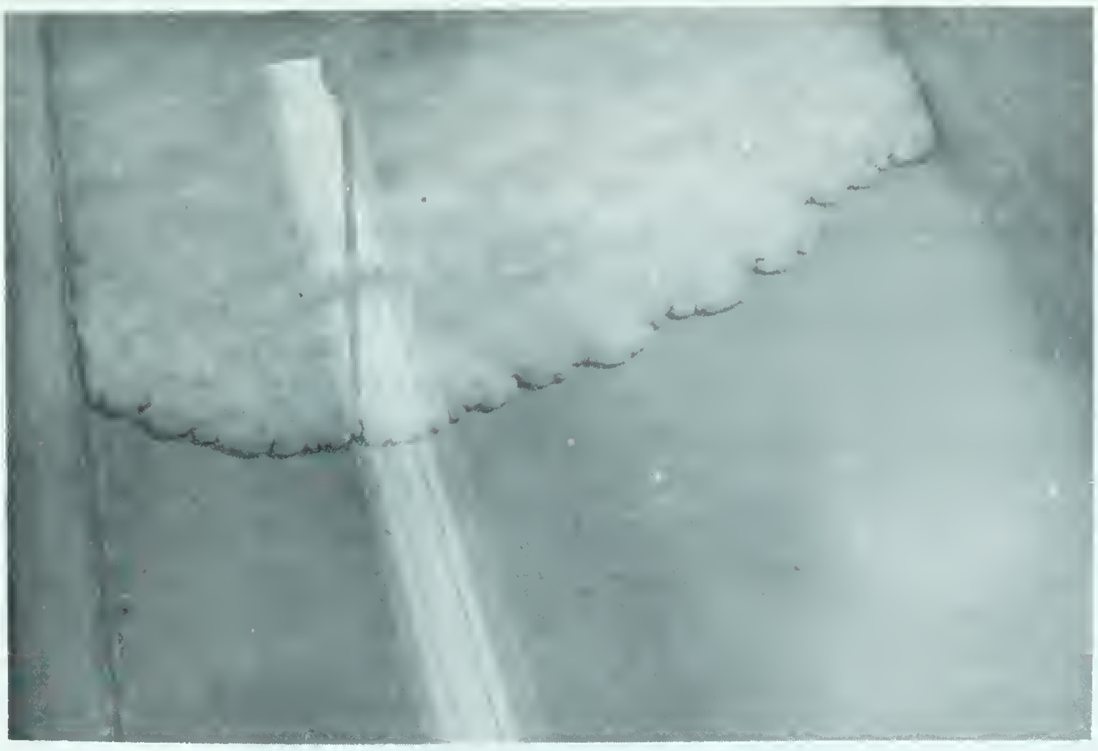


Photograph No. 15

Another photograph near section 2.

Photograph No. 16

Close-up of density layer front through window at section 3.



Photograph No. 17

Density layer front between sections 3 and 4.

Photograph No. 18

Density layer front approaching section 4.

Photograph No. 19

Close-up of density layer front through window at section 5.

Photograph No. 20

Shows mixing at interface after the density layer front had passed section 2.

Photograph No. 21

Shows mixing at interface at section 3.

CHAPTER VI

6.1 ANALYSIS OF DATA

The data collected in the laboratory have been analysed in the following pages. An attempt has been made to study the interdependence of , R_b and $\frac{d}{D}$. To be able to compare the results of the present investigations with those of other investigators namely Ippen and Harleman, Levi and Raynaud, their curves and experimental points were reduced to the same basis as used in this study. For comparison, the different definitions are given in the table below:

	τ_0	λ_0	λ_1	λ	R_b
Ippen and Harleman	$C_f\,(e+\Delta e)\,\frac{V_b^2}{2}$	C_f	$\alpha . C_f$		$\frac{V_b d}{\nu_b}$
Levi	$\lambda_0\,\gamma_1\,\frac{V_b^2}{2g}$	λ_0	λ_1	$\lambda_0+\lambda_1\frac{1}{1-d/D}$	$\frac{V_b d}{\nu_b}$ (ASSUMED)
Raynaud	$\frac{\lambda_2}{4}(e+\Delta e)\frac{V_b^2}{2}$	λ_2	λ_1	$\lambda_2+\lambda_1\frac{e}{e+2d}$	$4\,\frac{V_b . R_H}{\nu_b}$
Present Study	$\lambda_0(e+\Delta e)\frac{V_b^2}{2}$	λ_0	λ_1	$\lambda_0+\lambda_1\frac{1}{1-d/D}$	$\frac{V_b d}{\nu_b}$

Here $(e+\Delta e) = \frac{\gamma_1}{g}$

$$C_{f\,\text{Ippen and Harleman}} = \lambda_{0\,\text{Levi}} = \left(\frac{\lambda_2}{4}\right)_{\text{Raynaud}} = \lambda_{0\,\text{Present Study}}$$

$$(\alpha \cdot C_f)_{\text{Ippen and Harleman}} = \lambda_{1\,\text{Levi}} = \left(\frac{\lambda_1}{4}\right)_{\text{Raynaud}} = \lambda_{1\,\text{Present Study}}$$

Ippen and Harleman did not use total coefficient of friction λ. So that the results of the present study could be compared with those of Ippen and Harleman, λ was worked out by $\lambda = C_f\left(1+\frac{\alpha}{1-d/D}\right)$, α was taken equal to 0.64 and $C_f = \frac{1}{0.114 R_b}$ for their mean curves. Raynaud's λ_2, λ_1 or λ were divided by 4 and the values of R_b were reduced to $\frac{V_b d}{\nu_b}$. Raynaud's λ could not be transformed to the exact adopted definition of λ, because data regarding D was not available. For Levi's points, since much information was not available from his paper, it was assumed that R used in his paper had the definition $R_b = \frac{V_b d}{\nu_b}$.

Computations of Basic Parameters

The discharge passing through the flume was measured over the weir which was calibrated earlier. The bed, interface and water surface elevations were read at intervals, at test sections 1 to 6. From these, the thickness of the density layer d and the total depth of flow D were computed.

In order to determine the mean velocity of flow V_b of the density layer, the velocity profile was traced in the two layers by injecting a dye, prepared from kerosene oil, ethylene chloride and blue pigment. The dye prepared for the lower layer was heavier than for the top layer. The mean velocity of the top layer was also worked out from the same plot. This was quite small as compared to V_b. For runs with clay, the dye injected in the lower layer was not visible from the outside. Therefore, for the test runs 3,4,5 and 8, the mean velocity V_b was computed by knowing the discharge over the weir and the velocity profile of the upper layer. The assumption made was that the velocity profile in the lower layer was parabolic. Such calculations are shown in Appendix E for the test runs 3 and 8. For the test runs 4 and 5, these calculations are not given.

To compute the mean salinity of the two layers, salinity profile was traced by the conductivity probes. To work out the mean specific gravity of clay mixture of the two layers, samples were drawn at the test sections 2 to 6, from different depths and the hydrometer analysis was carried out. The specific gravity profiles were then drawn and the mean was worked out. These mean values of salinity and specific gravities were then used for the calculations of the mean mass densities ρ and $(\rho+\Delta\rho)$ of the top and the bottom layer respectively.

Knowing the temperature of water in the flume, and the mean concentration, the coefficients of viscosities or apparent viscosities of the two layers μ and μ_b were found by interpolation.

Knowing the above values, various parameters were worked out at the sections where velocity was measured. Those are given below:

1. Reynolds number of the density layer, $R_b = \frac{V_b d}{\nu_b}$

2. Reynolds number of the total depth of flow, $R = \frac{V_b . D}{\nu_b}$

3. Ratio of the properties of the bottom and top fluids $= \frac{\mu_b(\rho + \Delta\rho)}{\mu \rho}$

4. The non-dimensional thickness of the density layer $= \frac{d}{D}$

5. Total coefficient of friction $\lambda = \frac{\left[\alpha_1 V_b^2/2 - \Delta\rho/(\rho+\Delta\rho)\right]}{V_b^2/2gd} \frac{d(d)}{ds}$

for the level flume.

This was obtained from the Levi's paper quoted in the bibliography. Here α_1 is the momentum correction factor. Levi defined α_1 as

$$\alpha_1 = \frac{\int_0^D v^2 dy}{V_b^2 d}$$

To take into account the variation in mass density, α_1 was worked out by the following definition,

$$\alpha_1 = \frac{\int_0^d \rho \, v^2 dy}{\rho_{AV} V_b^2 d}$$

where ρ = Mass density at any depth y

ρ_{AV} = Average mass density of the bottom layer

Instead of D, integral was taken over small d because the velocity of the top layer was very small. The values of α_1, were calculated for the first test. The variation was from 1.01 to 1.06. Since the values were not very much different from 1, for all subsequent calculations α_1 was taken as unity.

To work out $\frac{d(d)}{ds}$, say velocity was observed at section 3. Then

$$\frac{d(d)}{ds} = \frac{d_2 - d_4}{\text{Distance between sections 2 and 4}}$$

where d_2 and d_4 are the thicknesses of the density layer at sections 2 and 4.

For the sloping flume, λ was given by

$$\lambda = 2\alpha_1 \frac{d(d)}{ds} + \frac{\Delta\rho}{\rho + \Delta\rho}\left[I_0 - \frac{d(d)}{ds}\right]\frac{2gd}{V_b^2}$$

where α_1 was taken as unity and I_o is bed slope. In this case $\frac{d(d)}{ds}$, say at section 3, is given by

$$\frac{d(d)}{ds} = \frac{d_4 - d_2}{\text{Distance between sections 2 and 4}}$$

Then λ_o was worked out by

$$\lambda_o = \frac{\lambda}{\left(1 + \frac{\alpha}{1 - d/D}\right)}$$

Here α was taken as 0.64 as pointed out in Ippen and Harleman (1952).

The data were then plotted as λ vs. R_b for different values of $\frac{d}{D}$ and $\sqrt{\lambda_o}$ vs. R_b.

6.2 Discussion of Results

The critical values of R_b and F_b are 1000 (Task Committee, 1963) and 1 respectively. The variation in R_b obtained in the present study vis a vis the corresponding values of other investigators is given below:

	VARIATION IN R_b
Present Study	169 - 2370
Ippen and Harleman	15 - 1000
Raynaud	347 - 6250
Levi	3900 - 23300

As expected, the concentration of salt or clay in water flowing over the weir decreased with time. But the interesting point was that the salinity or clay concentration at the bottom of the lower layer in the flume stayed at the maximum value much longer. The reason for this may be found in the fall velocity of the particles for runs with clay.

Another observation is that the interface, in reaching near the top, took shorter time with salt runs than with clay runs. For salt runs,

this might be due to the property of diffusion of salt, whereas for runs with clay, the fall velocity of the clay particles might have affected the results. For comparison, the duration of the various tests with corresponding effects on the interface, are given in the following table:

TEST RUN	Initial Concentration of Salt Mixture in Head Tank. % by weight	Initial Specific Gravity of Clay Mixture in Head Tank.	Time for Which Test was Run. Hours	Position of Interface at Section 4. d/D	
				Start of Test	End of Test
1	0.455	-	10	0.62*	1.00
2	1.000	-	12	0.55*	0.78/
3	-	1.0024	90	0.50**	0.57
4	-	1.0068	70	0.54**	0.80
5	-	1.0075	68	0.54**	0.88
6	2.080	-	24	0.58**	0.94
7	2.000	-	24	0.45**	0.88
8	-	1.0070	24	0.56**	0.84

* Measured 1 hour after start of test.

** Measured 2 hours after start of test.

/ Measured 1 hour before end of test.

It was also observed that in all the runs, the thicknesses of the density currents were non-uniform. These thicknesses went on varying during the tests.

1. "λ - R_b" Plot

Refer to figure F - 28 on page 239. In the data plotted, for some of the experimental points the value of $\frac{d}{D}$ is given. In the same figure, the mean curves due to Raynaud and Levi are also drawn. Raynaud's λ has a

different definition i.e., $\lambda = \lambda_0 + \lambda_1 \ell/(\ell + 2d)$ whereas the experimental points define $\lambda = \lambda_0 + \lambda_1/(1 - d/D)$. The present results, therefore, cannot strictly be compared with those of Raynaud. For the derivations of his equations, Raynaud assumed uniform depth of flow. Levi worked with high Reynolds numbers and low values of $\frac{d}{D}$ (between 0.35 to 0.45), whereas the present study was made with comparatively low Reynolds numbers and with values of $\frac{d}{D}$ varying from 0.340 to 0.917. However the trend of the two plots is nearly the same. The lines due to Ippen and Harleman for $\alpha = 0.64$ and $\frac{d}{D} = 0$, 0.5, 0.9 and 0.99 are also drawn. In fact Ippen and Harleman did not consider the effect of d/D on λ_0 or λ. The fit of the experimental points with these lines is not very good, probably due to different values of $\frac{B}{D}$ and due to different surface tension. The working velocities were very low. Maximum mean velocity of the lower layer was 1.2 inches per second. Their measurements may not be very precise in the present case. The procedure followed for working out the values of λ was essentially that of Levi, who considered the flow to be non-uniform. The flow in the case of the present study was found to be non-uniform. In any case the overall trend is that large values of $\frac{d}{D}$ are associated with high values of λ. To verify the effect of d/D on λ, different points were grouped and their means worked out. These mean points are plotted in the Figure F-28. They clearly show that with the increase in d/D, λ also increases. It may be mentioned that Ippen and Harleman worked with a uniform depth of flow.

While plotting the above data, the values of $\mu_b(\rho+\Delta\rho)/\mu\rho$ were overlooked, as the variation in it was from 1.006 to 1.560. This may not cause much difference in the value of α and thus in λ_1 and λ. The values of $\frac{V_i}{V_b}$ for two different values of $\mu_b(\rho+\Delta\rho)/\mu\rho$ due to Keulegan are given in the following table:

$\frac{\mu_b(\rho+\Delta\rho)}{\mu\rho}$	$\frac{V_i}{V_b}$	J	α
1	0.59	0.138	0.640
10	0.35	0.107	0.823

The values of J and α were calculated from the equations (B-6) and (E-1) given in the Resumé of Literature.

The scatter of the data may be due to the simplifying assumptions of neglecting the coefficient of diffusion for runs with salt or considering the sediment to be colloidal or neglecting the effect of $\frac{B}{D}$ or $\frac{\mu_b(\rho+\Delta\rho)}{\mu\rho}$ or due to not precise measurements of very low velocities.

To sum up, it can be stated that $\frac{d}{D}$ depends primarily upon the total coefficient of friction λ and the Reynolds number of the density layer R_b.

2. "$\sqrt{\lambda_0}$ - R_b" Plot

Refer to figure F-29 on page 240. λ_0 was worked out by

$$\lambda_0 = \frac{\lambda}{1 + \frac{\alpha}{1 - d/D}}$$

In the plot $\sqrt{\lambda_0}$ versus R_b, the line due to Ippen and Harleman has also been drawn. The experimental points lie above this line. However, the general trend of the plot is the same. For $R_b > 1000$ (critical value), the points come closer to the Ippen and Harleman line.

The plotted points indicate that as R_b increases, λ_0 increases. These points were grouped and their means were calculated. These mean points are plotted in the Figure F-29, indicating that λ_0 also increases with d/D. In the calculation of λ_0, plotted on this figure, α was taken as 0.64. However, the values of α were subsequently computed from the velocity diagrams, and the values of λ_0 re-computed. These values of λ_0

were not much different from those calculated with $\alpha = 0.64$ and used in $\sqrt{\lambda_0}$ vs. R_b plot.

CHAPTER VII

7. SUMMARY AND CONCLUSIONS

This chapter summarizes the findings of the laboratory research and makes some suggestions for further research on the topic.

7.1 Summary

The study of the thickness of density currents in reservoirs was conducted in a flume 120 feet long; 3 feet wide and 3 feet deep for zero, 1 in 360 and 1 in 180 slopes. Density currents were recirculated with salt and aluminium silicate beneath clear water ponded in a flume. Thus it was possible to run a test with one setting for many hours. Four tests were run with zero slope, of which the first two were made with salt and the remaining two with clay. The next two tests, one with clay and one with salt, were run with 1 in 360 slope. Then the last two tests, again with salt and clay respectively, were run with 1 in 180 slope. The data collected from these test runs made possible the calculations of various parameters described in the previous chapter. These parameters were arrived at with the help of dimensional analysis. This had indicated that the non-dimensional thickness of the density layer $\left(\frac{d}{D}\right)$ may depend on the total coefficient of friction (λ), the Reynolds number of the density layer (R_b) and the ratio of the fluid properties of the bottom and top layer $\mu_b(\rho+\Delta\rho)/\mu\rho$. The variation in the parameter $\mu_b(\rho+\Delta\rho)/\mu\rho$ was from 1.006 to 1.560, which may not make any appreciable change in λ. Its effect was therefore not considered. The resulting plot between λ and R_b for different values of $\frac{d}{D}$, as given in the figure F - 28, shows the interdependence of these three parameters. This makes it possible to say that for large values of $\frac{d}{D}$, the points plot higher, which is also indicated by the data of Ippen and Harleman plotted to the same co-ordinates.

In the second plot between $\sqrt{\lambda_o}$ and R_b, the Ippen and Harleman's

line is also drawn. The experimental points plot above this line generally showing larger values of λ_o for the same R_b. This may be due to different values of $\frac{B}{D}$, $\mu_b(\rho+\Delta\rho)/\mu\rho$ or different surface tension. Ippen and Harleman work with uniform depth of flow, whereas for the experimental data, the Levi approach of non-uniform flow was adopted. In the experiments run, the flow was actually found to be non-uniform.

7.2 Conclusions

The friction factor of the density layer, λ, was found to depend primarily upon the Reynolds number of the density layer, R_b, and on the non-dimensional thickness of the density layer, d/D.

7.3 Recommendations for Future Study

Here only the thickness of the density layer has been studied. Further work can be done along the following lines:

1. To consider the effect of the fall velocity of particles on the thickness of the density layer.
2. To study the effect of $\frac{B}{D}$ and $\frac{\mu_b(\rho+\Delta\rho)}{\mu\rho}$ on the thickness of the density layer.
3. To design a current meter capable of measuring the velocity distribution more accurately than was possible here, in order to compute the values of J and α for each test.

8. BIBLIOGRAPHY

1. Govier, G.W., "Interpretation of Rheological Data for Engineering Use," The Engineering Journal, Vol. 43, No. 3.

2. Harleman, D.R.F.; McDougall, D.W.; Galvin, C.J.; and Hooper, J.A., "An Analysis of One Dimensional Convective Diffusion Phenomena in an Idealised Estuary," Technical Report No. 42, M.I.T. Hydrodynamics Laboratory, January, 1961.

3. Howard, C.S., "Density Currents in Lake Mead," Proceedings Minnesota International Hydraulics Convention (I.A.H.R. & A.S.C.E.) St. Anthony Falls Hydraulics Laboratory, Minneapolis, Minnesota, September, 1953.

4. Ippen, A.T., and Harleman, D.R.F., "Steady State Characteristics of Subsurface Flow," in "Gravity Waves," National Bureau of Standards Circular 521, November, 1952.

5. Keulegan, G.H., "Laminar Flow at the Interface of Two Fluids," Research Paper RP 1591, Journal of Research, National Bureau of Standards, Vol. 32, June, 1944.

6. Lambe, T.W., "Soil Testing for Engineers," John Wiley & Sons, Inc., May, 1960.

7. Lane, E.W., "Sediment Engineering as a Quantitative Science," Inter-Agency Sedimentation Conference, U.S. Bureau of Reclamation, May, 1947.

8. Levi, I.I., "Theory of Underflows in Storage Reservoirs," Eighth Congress Proceedings of I.A.H.R., Vol. 2, Montreal, 1959.

9. Metzner, A.B., "Non Newtonian Technology: Fluid Mechanics, Mixing and Heat Transfer," University of Delaware, Newark, Delaware.

10. Raynaud, J.P., "Etude des Courants d'eau Boueuse Dans les Retenues," New Delhi: Fourth Congress on Large Dams of International Commission on Large Dams of the World Power Conference, New Delhi, January, 1951.

11. Streeter, V.L., "Handbook of Fluid Dynamics, First Edition, Section 26, Stratified Flow," McGraw-Hill Book Company, Inc., 1961.

12. Streeter, V.L., "Fluid Mechanics", Third Edition, McGraw-Hill Book Co., Inc., 1962.

13. Task Committee on Preparation of Sedimentation Manual and Committee on Sedimentation Hydraulics Division, Progress Report, "Sediment Transportation Mechanics: Density Currents," Journal of Hydraulics Division, Proceedings of the A.S.C.E., September, 1963.

APPENDIX A

A. Weir Calibration

The flow rate was determined by a 60 degree vee-notch weir located as shown on Figure A-1. The head on the weir was determined by point gauges operating in stilling wells placed upstream and downstream. Calibration was carried out using the laboratory weighing tanks.

The discharge equation found was

$$Q = 1.419 \phi H^{2.499}$$

where ϕ , the submergence correction factor, is a function of the ratio h/H , that is the ratio of downstream to upstream depths measured above the point of the vee notch.

APPENDIX B

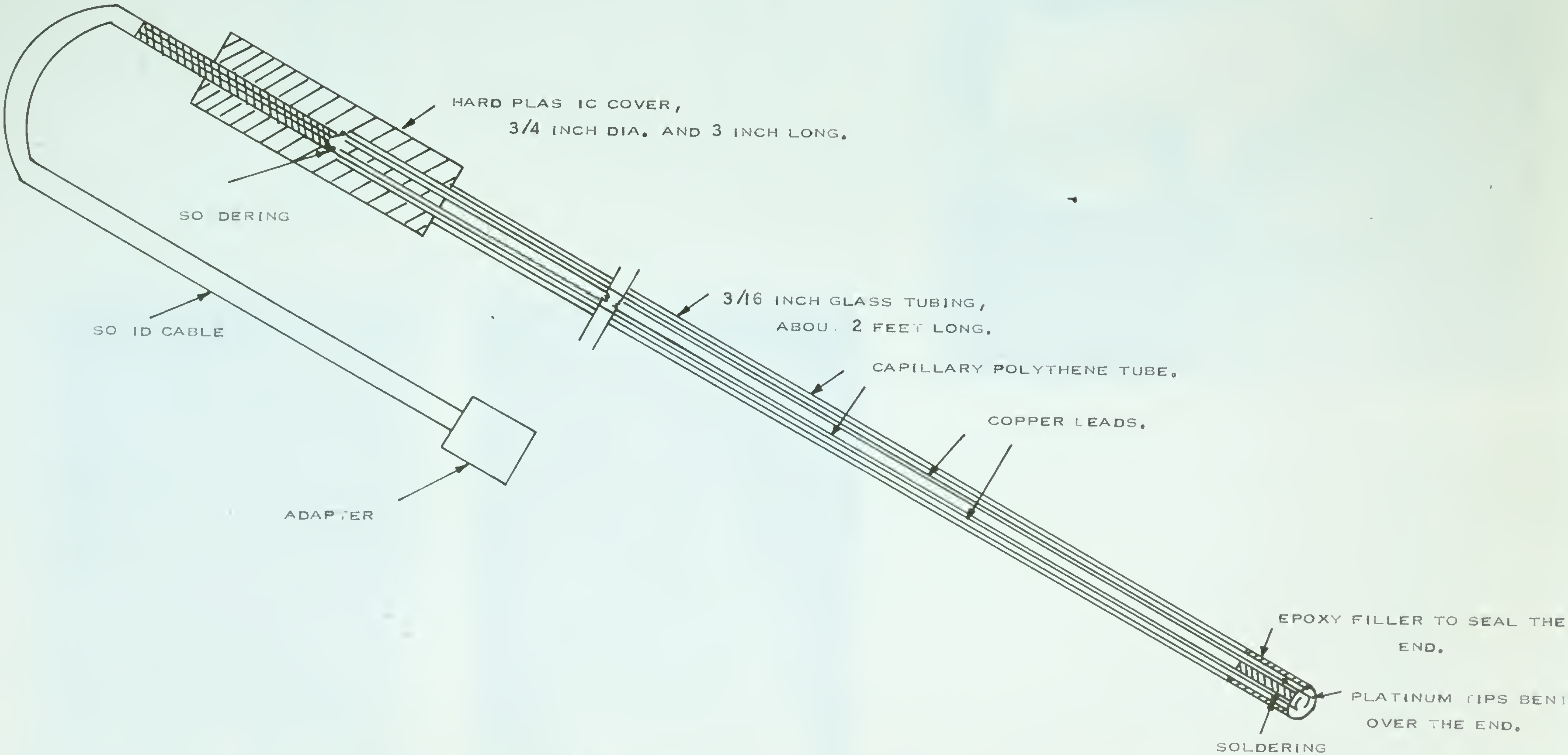
B-1 Conductivity Probes and Wheatstone Bridge Circuits

In order to measure the concentrations of salt at different depths in the flume, conductivity probes were made. The various details are given in Figure B-2 (Also refer photograph No. 23). The basic design for the probe was taken from reference 2. Wheatstone Bridge circuits, as illustrated in Figure B-3 (Also refer photograph No. 24) were designed.

B-2 Calibration of Conductivity Probes

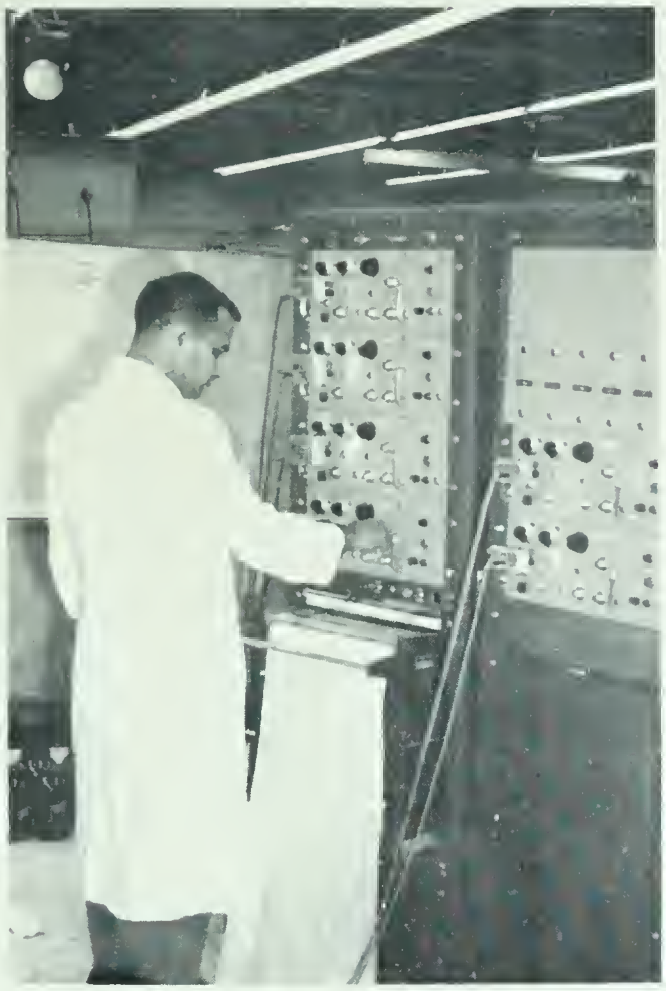
The conductivity of salt solution follows a square root law. To get better results, it was considered desirable to calibrate each probe in various ranges. The ranges selected were 0 - 0.5%, 0 - 1%, 0 - 2%, 0.1 - 1%, 1 - 2% of salinity by weight. In order to minimise instrumental variations, each probe was numbered and allotted a bridge box and a recorder circuit.

The calibration of each probe and its circuit was checked by immersion



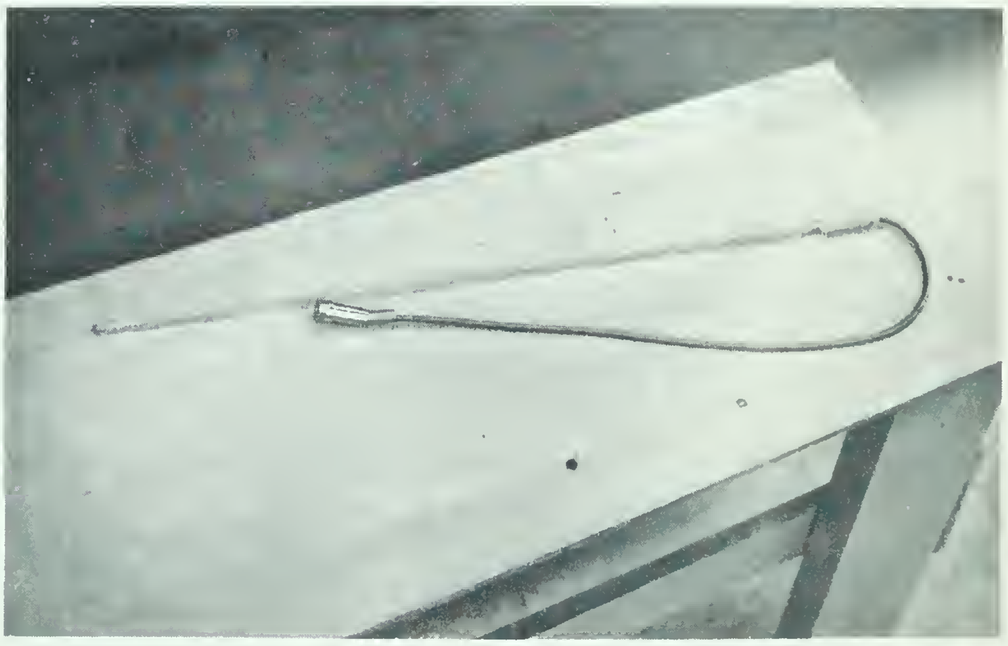
SCHEMATIC SECTION OF A CONDUCTIVITY PROBE.

FIGURE B – 2



Photograph No. 22

Shows the author balancing channel No. 6 of the Sanborn equipment for Test Run 2.

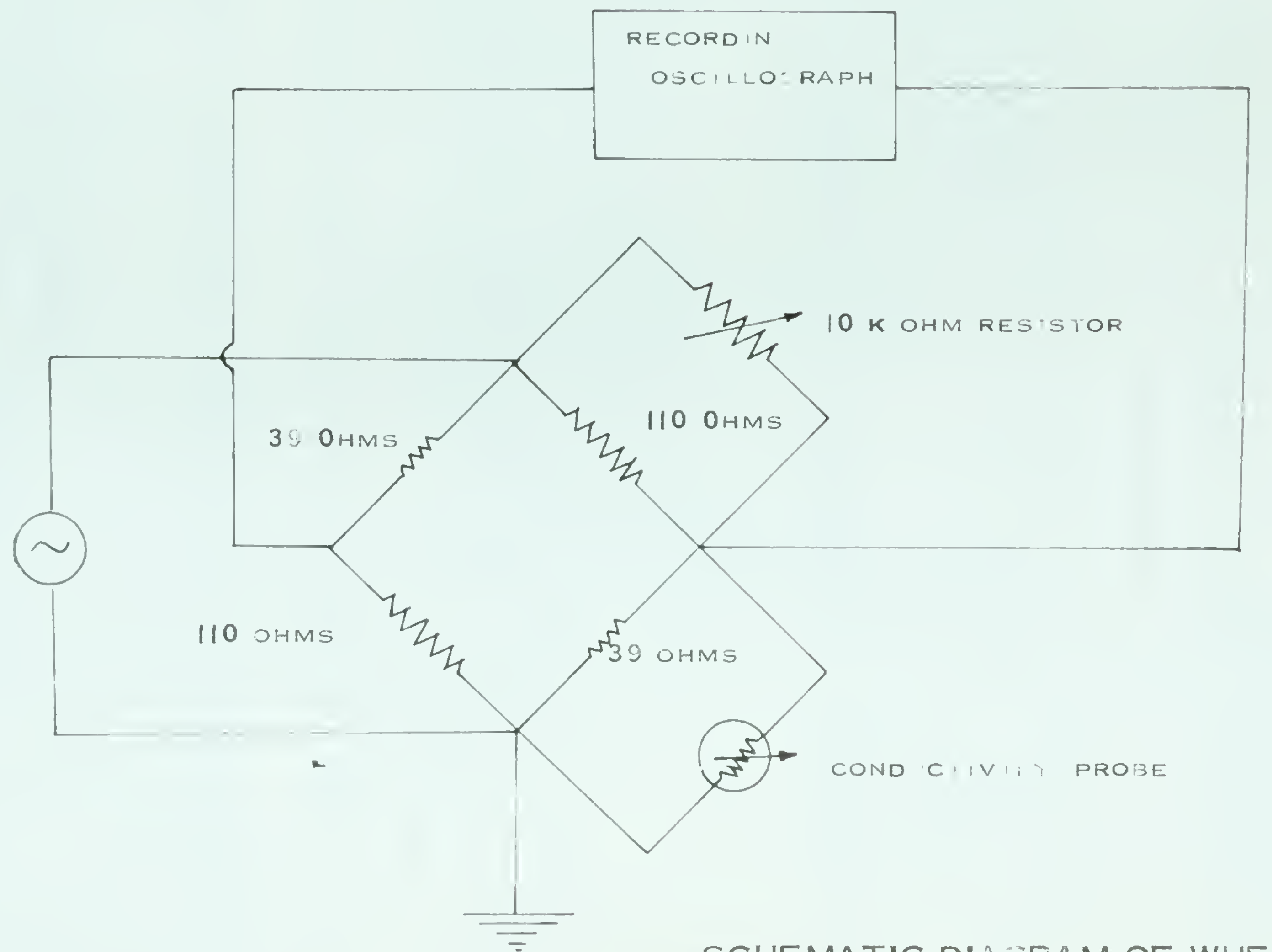


Photograph No. 23

Conductivity Probe.

Photograph No. 24

Shows 2 Wheatstone Bridge boxes; No. 2 is open and No. 4 is closed.



SCHEMATIC DIAGRAM OF WHEATSTONE BRIDGE CIRCUIT.

FIGURE B – 3

in standard solutions at frequent intervals during the tests.

APPENDIX C

C-1 Measurement of viscosities

The viscosities of saline and muddy waters at different concentrations were found out with the help of V.G. Fann Viscometer Model 35. (Refer photograph No. 25). The motor in the viscometer could be run at different speeds, namely 6, 12, 100, 200, 300 and 600 revolutions per minute. This moved the rotor dipped in a solution which transmitted a torque on the stator through the fluid filling the annular zone between the rotor and the stator. This torque could be read in terms of deflection in degrees, θ. To raise and maintain the temperature of a sample, a Porta Bath (Refer photograph No. 26) along with a thermometer was used.

C-2 Calibration of Torsion Spring

To work out the spring constant used in the viscometer, two samples of mineral oils of known viscosities were used. These oils were Newtonian fluids. The calculations gave the mean value of the spring constant, K as 74.5. For non-Newtonian fluids it was found that the rate of shear, du/dr was given by

$$\frac{du}{dr} = 1.574N \left[1 + 0.0678 \left(\frac{1}{n''} - 1\right) + 0.000697 \left(\frac{1}{n''} - 1\right)^2 \right]$$

C-3 Viscosities of fluids

(a) Salt solutions (Newtonian Fluids)

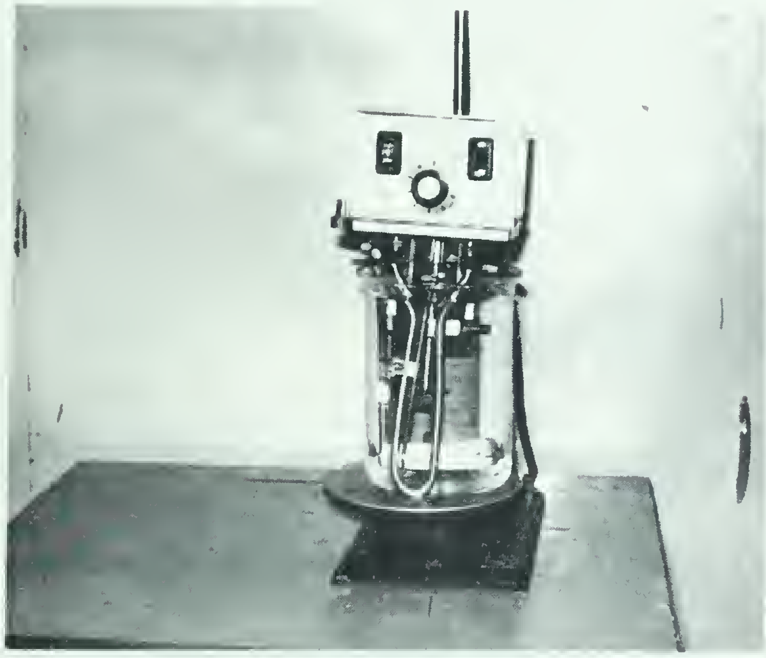
The coefficient of viscosity, μ was given by

$$\mu = \frac{K}{1.573} \cdot \frac{\theta}{N}$$

$$= \frac{74.5}{1.573} \frac{\theta}{N} = 47.3 \frac{\theta}{N} \quad \text{C-Poises}$$

Photograph No. 25

V. G. Fann Viscometer, Model 35.

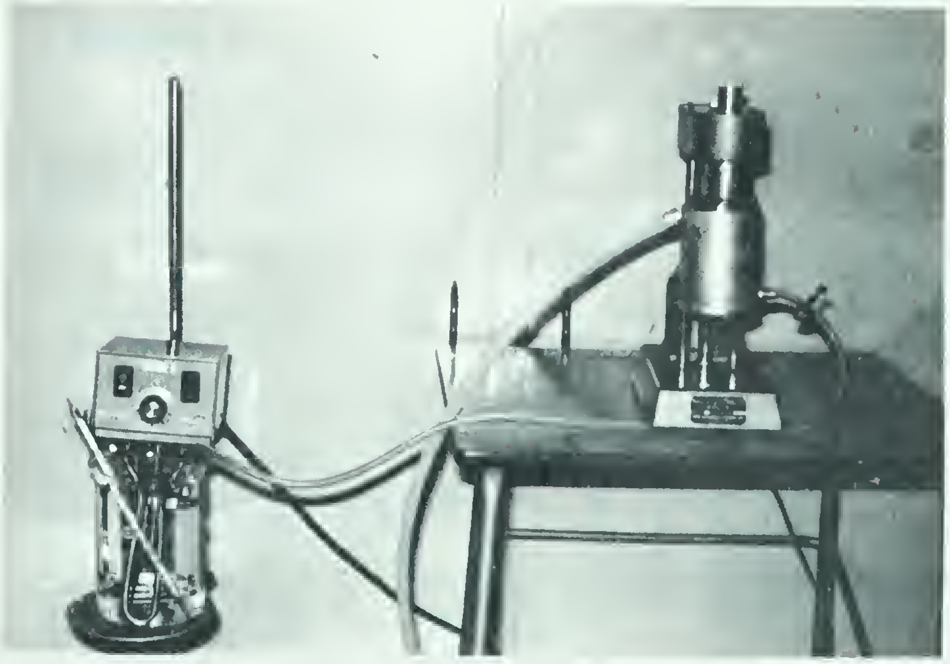


Photograph No. 26

Porta Bath for constant temperature.

Photograph No. 27

Shows set-up for viscosity tests.



Salt solutions selected, were 0.5%, 1% and 2% by weight. The viscosities were worked out at three different temperatures. The curves drawn through the points are given in Figure C-4.

(b) Clay solutions (Non-Newtonian Fluids)

Clay mixtures were pseudo-plastic. But in the concentrations tested a Bingham plastic model could be approximately fitted. Therefore this approach was adopted. Here

$$\tau = \tau_Y + \mu_a \frac{du}{dr}$$

where τ_Y = Yield stress of the material

μ_a = Apparent coefficient of viscosity

$\frac{du}{dr}$ = Velocity gradient

$$= 1.574\, N\left[1 + 0.0678\left(\frac{1}{n''} - 1\right) + 0.000697\left(\frac{1}{n''} - 1\right)^2\right]$$

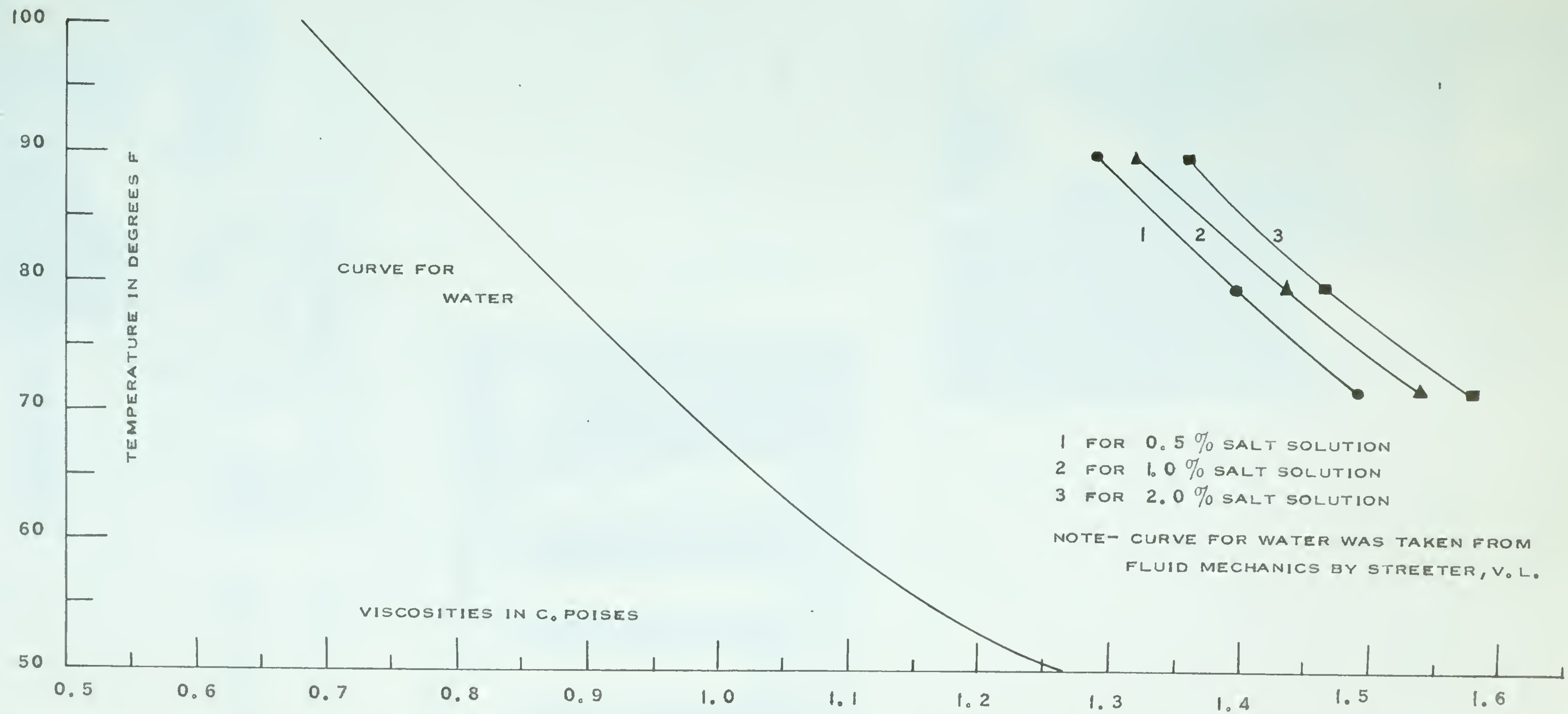
$$\tau = K\theta = 0.745\,\theta \text{ dynes/cm}^2$$

Clay solutions tried were 0.5, 1, 2 and 4% by weight. The calculations were made at three different temperatures. The data were then plotted in the form of τ vs. du/dr, as shown in Figure C-5.

APPENDIX D

D-1 Hydrometer Analysis of Aluminium Silicate

In order to study the fall velocity of clay particles, hydrometer analysis was carried out. For this four samples of clay from different bags were taken. These were mixed with distilled water and 10 M.L. of Calgon of 6% concentration. Each suspension was mixed in a mixer (Refer Photograph No. 28) for about 10 minutes. The specimens were then washed in graduated cylinders and enough distilled water was added to bring it up to 1000 c.c. mark. The samples were further mixed by



VISCOSITY CURVES FOR SALT SOLUTIONS.

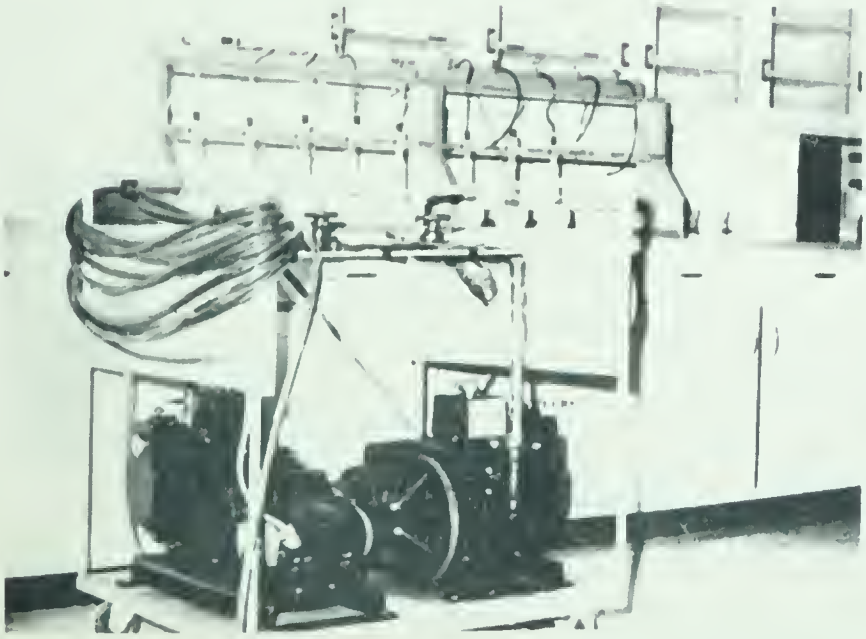
FIGURE C – 4

Photograph No. 28

Shows soil being broken down into individual particles by a mixer.

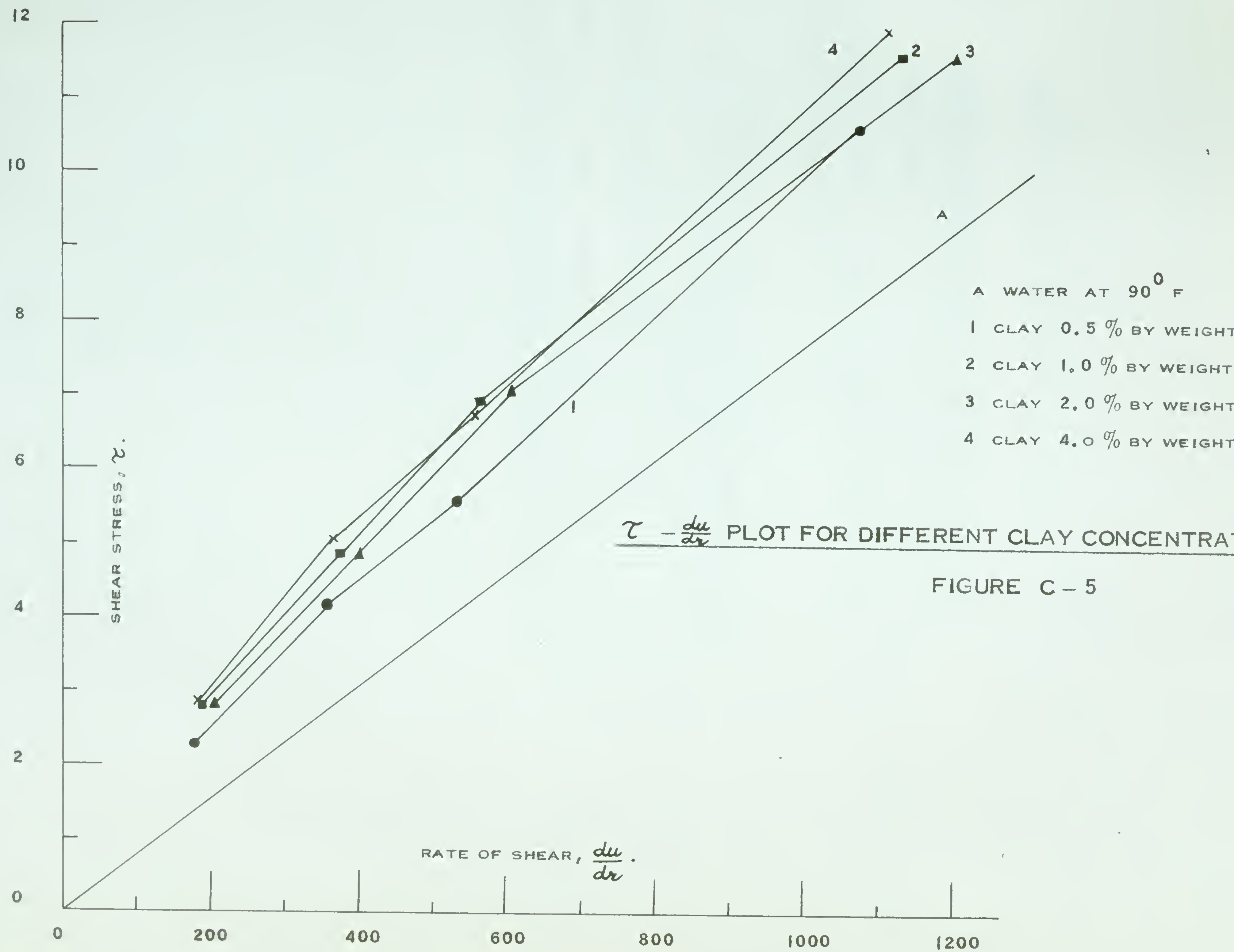
Photograph No. 29

Hydrometer analysis of samples.



Photograph No. 30

Shows air being sucked out of samples for specific gravity tests.



$\tau - \frac{du}{dr}$ PLOT FOR DIFFERENT CLAY CONCENTRATIONS AT 90^{0} F.

FIGURE C – 5

closing the open ends of the jars and turning those upside down and back. After 1 minute, the hydrometer readings were then taken at 1/4, 1/2, 3/4, 1, 2, 4, 8, 15, 30 minutes and 1, 2, 4, 8, 24, 48, 72, 96, 120 and 144 hours. Every time hydrometer and temperature readings were taken. To the hydrometer readings corrections for meniscus, temperature and dispersing agent were applied. The diameters of particles were then read from the calibration chart of the hydrometer.

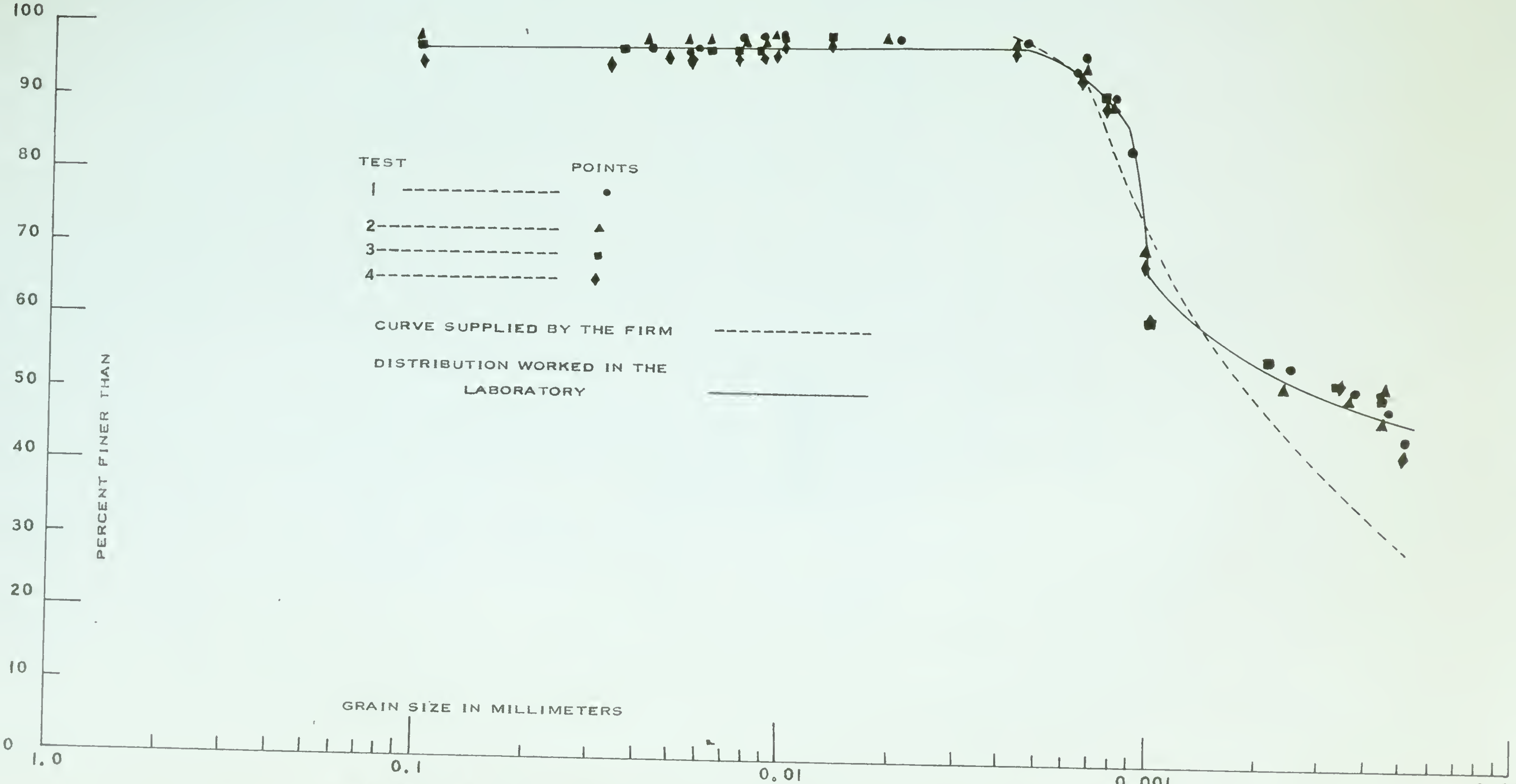
After the final reading, the suspensions were dried and weighed.

D-2 Specific Gravity Tests of Aluminium Silicate

Eight tests were run for specific gravity, taking two samples from each bag. The mean value of specific gravity came out to be 2.58, with individual test values ranging from 2.53 to 2.65.

D-3 Particle Size Distribution of Aluminium Silicate

After working out the diameters of particles settling at different times and mean specific gravity, the calculations for weight W% , finer than each size, were made and plotted against the particle diameter in microns. The particle size distribution curve is plotted in Figure D-6.



PARTICLE SIZE DISTRIBUTION CURVE OF ALUMINIUM SILICATE.

FIGURE D – 6

APPENDIX E

TEST RUN 1

General Data

Material Used: Salt

Dye Used: Flouresene

Flume: Level

Sluice Gate Opening: 3"

Test Started: 11:30 A.M. on 23.7.64

Duration of Test: 11 Hours

Observation Time: 1, 2, 3, 4, 5, 7, 8, 9, 10, and 11 hours after the start of the test.

Data of Conductivity Probes

Conductivity Probe No.	Attenuator Reading	Range Set	Used at Section	Bed Reading Ft.
2.	x200	0 to 1% salinity concentration by weight	2	1.101
3.	x100		3	1.270
4.	x200		4	1.253
5.	x200		5	1.397
6.	x200		6	1.292

Flow Data

Flow over weir - Free

Gaugereading upstream of weir = 0.872 Ft.

Reading for no flow = 0.589 Ft.

∴ Head over weir = 0.283 Ft.

From flow curve for free flowing weir (Appendix A)

$$Q = 0.061 \text{ C.F.S.}$$

PROFILE MEASUREMENTS

Test Run: 1

Table: 1 - P - 1

Time since test started: 1 Hour

Section	Bed Reading. Ft.	Density Layer Reading. Ft.	*Top Reading. Ft.	d Col. 3- Col. 2 Ft.	D Col. 4- Col. 2 Ft.	Λ_1	C_0 %	H Ft.
1	2	3	4	5	6	7	8	9
1	0.072	-	0.650	-	0.578	●		
2	0.236	0.655	0.796	0.419	0.560			
3	0.071	0.469	0.643	0.398	0.572	5.1	0.20	0.283
4	0.104	0.458	0.675	0.354	0.571			
5	0.122	0.413	0.698	0.291	0.576	T = 72°F		
6	0.098	-	0.677	-	0.579			

Where d = Thickness of density layer in feet.

D = Total depth of flow in feet.

Λ_1 = Deflection of recorder for water flowing over weir.

Λ = Deflection of recorder.

C_0 = Concentration percent by weight, taken from Λ - C plot of the probe used.

H = Head over weir in feet.

*Top readings went on decreasing consistently throughout the test, because there was a leakage from the pump at the tail end of the flume.

●Probe No. 2 was used. Refer Appendix B for its calibration curve. Salinity of water in the beginning of the test was 0.455% by weight.

NOTE: These signs will have the same interpretation throughout all profile measurements.

Table: 1 - P - 2

Time since test started: 2 Hours .

Section.	Bed Reading. Ft.	Density Layer Reading. Ft.	*Top Reading Ft.	d Col. 3- Col. 2 Ft.	D Col. 4- Col. 2 Ft.	λ_1	C_0 %	H Ft.
1	2	3	4	5	6	7	8	9
1	0.072	-	0.649	-	0.577			
2	0.236	0.723	0.795	0.487	0.559			
3	0.071	0.520	0.642	0.449	0.571	5	0.195	0.283
4	0.104	0.509	0.674	0.405	0.570			
5	0.122	0.473	0.697	0.351	0.575	T = 72°F		
6	0.098	-	0.676	-	0.578			

Table: 1 - P - 3

Time since test started: 3 Hours

1	0.072	-	0.647	-	0.577			
2	0.236	0.792	0.792	0.556	0.556			
3	0.071	0.557	0.640	0.486	0.569	4.9	0.190	0.282
4	0.104	0.533	0.673	0.429	0.569			
5	0.122	0.495	0.695	0.373	0.573	T = 72.5°F		
6	0.098	-	0.675	-	0.577			

Table: 1 - P - 4

Time since test started: 4 Hours

1	0.072	-	0.646	-	0.574			
2	0.236	0.792	0.792	0.556	0.556			
3	0.071	0.583	0.640	0.512	0.569	4.8	0.185	0.282
4	0.104	0.555	0.673	0.451	0.569			
5	0.122	0.523	0.695	0.401	0.573	T = 73°F		
6	0.098	-	0.675	-	0.577			

Table: 1 - P - 5

Time since test started: 5 Hours

Section	Bed Reading Ft.	Density Layer Reading Ft.	*Top Reading Ft.	d Col. 3- Col. 2 Ft.	D Col. 4- Col. 2 Ft.	Ω_1	C_0 %	H Ft.
1	2	3	4	5	6	7	8	9
1	0.072	-	0.645	-	0.573			
2	0.236	0.792	0.792	0.556	0.556			
3	0.071	0.598	0.637	0.527	0.566	4.8	0.185	0.282
4	0.104	0.567	0.672	0.463	0.568			
5	0.122	0.535	0.694	0.413	0.572	T= 73°F		
6	0.098	-	0.673	-	0.575			

Table: 1 - P - 6

Time since test started: 7 Hours

1	0.072	-	0.644	-	0.572			
2	0.236	0.790	0.790	0.554	0.554			
3	0.071	0.635	0.635	0.564	0.564	4.8	0.185	0.282
4	0.104	0.587	0.670	0.483	0.566			
5	0.122	0.546	0.693	0.424	0.571	T= 73°F		
6	0.098	-	0.672	-	0.574			

Table: 1 - P - 7

Time since test started: 8 Hours

1	0.072	-	0.644	-	0.572			
2	0.236	0.788	0.788	0.552	0.552			
3	0.071	0.633	0.633	0.562	0.562	4.75	0.182	0.282
4	0.104	0.598	0.670	0.494	0.566			
5	0.122	0.557	0.690	0.435	0.568	T= 73.5°F		
6	0.098	-	0.671	-	0.573			

Table: 1 - P - 8

Time since test started: 9 Hours

Section	Bed Reading. Ft.	Density Layer Reading. Ft.	*Top Reading. Ft.	d Col. 3- Col. 2 Ft.	D Col. 4- Col. 2 Ft.	λ_1	C_0 %	H Ft.
1	2	3	4	5	6	7	8	9
1	0.072	-	0.644	-	0.572			
2	0.236	0.788	0.788	0.552	0.552	•		
3	0.071	0.633	0.633	0.562	0.562	4.75	0.182	0.282
4	0.104	0.619	0.669	0.515	0.565			
5	0.122	0.564	0.689	0.442	0.567	T = 74°F		
6	0.098	-	0.669	0	0.571			

Table: 1 - P - 9

Time since test started: 10 Hours

1	0.072	-	0.642	-	0.570			
2	0.236	0.787	0.787	0.551	0.551			
3	0.071	0.633	0.633	0.562	0.562	•		
4	0.104	0.668	0.668	0.564	0.564	4.75	0.182	0.282
5	0.122	0.571	0.688	0.449	0.566			
6	0.098	-	0.668	-	0.570	T = 74°F		

Table: 1 - P - 10

Time since test started: 11 Hours

1	0.072	-	0.642	-	0.570			
2	0.236	0.787	0.787	0.551	0.551	•		
3	0.071	0.633	0.633	0.562	0.562	4.70	0.180	0.282
4	0.104	0.665	0.665	0.561	0.561			
5	0.122	0.585	0.687	0.463	0.565	T = 73.5°F		
6	0.098	-	0.668	-	0.570			

VELOCITY MEASUREMENTS

Test Run 1

Section of observation: 5

Distance from upstream sluice gate: 85 Feet

*Table: 1 - V - 4

Time since test started: 4 Hours

Position From Bed. Ft.	Distance Travelled. Inches	Time Taken. Secs.	Velocity Inch/Sec.	Remarks
0.000	-	-	0.000	Bed.
0.021	12	36.0	0.333	Flow downwards.
0.042	12	34.0	0.353	" "
0.083	20	27.8	0.720	" "
0.284	21	27.7	0.758	" "
0.318	18	25.0	0.720	" "
0.490	-11	46.2	-0.238	Flow upwards.
0.510	-11	43.0	-0.256	" "
0.573	-12	77.0	-0.156	" "

Table: 1 - V - 5

Time since test started: 5 Hours

Position From Bed. Ft.	Distance Travelled. Inches	Time Taken. Secs.	Velocity Inch/Sec.	Remarks
0.000	-	-	0.000	Bed.
0.042	6.0	30.0	0.200	Flow downwards.
0.230	10.5	14.0	0.750	" "
0.355	11.0	15.6	0.705	" "
0.413	12.0	42.3	0.283	" "
0.472	12.0	44.0	0.273	" "
0.489	-12.0	60.8	-0.197	Flow upwards.
0.547	- 9.5	41.5	-0.229	" "
0.572	- 3.0	90.0	-0.033	" "

*For the first three sets of readings no velocity measurement was made. Effort was made to work with the OTT current-meter which did not pick up very low velocities.

Table: 1 - V - 6

Time since test started: 7 Hours

Position from Bed. Ft.	Distance Travelled. Inches	Time Taken. Secs.	Velocity. Inch/Sec.	Remarks
0.000	-	-	0.000	Bed.
0.021	6	30.0	0.200	Flow downwards.
0.042	10	15.8	0.633	" "
0.083	12	18.8	0.638	" "
0.299	12	17.0	0.706	" "
0.316	12	16.3	0.737	" "
0.488	-4	53.0	-0.075	Flow upwards.
0.504	-7	56.0	-0.125	" "
0.513	-6	31.0	-0.194	" "
0.538	-6	30.5	-0.197	" "
0.571	-3	60.0	-0.050	

Table: 1 - V - 7

Time since test started: 8 Hours

0.000	-	-	0.000	Bed.
0.021	12	31.0	0.387	Flow downwards.
0.062	12	28.5	0.421	" "
0.083	12	21.7	0.552	" "
0.125	10	17.7	0.565	" "
0.302	12	17.7	0.678	" "
0.435	12	48.3	0.248	" "
0.485	-6	55.0	-0.109	Flow upwards.
0.510	-6	31.3	-0.192	" "
0.526	-6	27.0	-0.222	" "
0.568	-6	28.1	-0.213	" "

Table: 1 - V - 8

Time since test started: 9 Hours

0.000	-	-	0.000	Bed.
0.042	12	30.0	0.400	Flow downwards.
0.062	6	13.0	0.462	" "
0.234	12	17.8	0.674	" "
0.275	12	16.8	0.715	" "
0.442	12	21.0	0.572	" "
0.467	-4	36.4	-0.110	Flow upwards.
0.509	-6	23.2	-0.259	" "
0.525	-8	40.2	-0.200	" "
0.567	-6	47.8	-0.125	" "

Table: 1 - V - 9

Time since test started: 10 Hours

Position from Bed. Ft.	Distance Travelled. Inches	Time Taken. Secs.	Velocity Inch/Sec.	Remarks
0.000	-	-	0.000	Bed.
0.021	12	35.8	0.335	Flow downwards.
0.042	12	30.0	0.400	" "
0.241	12	23.8	0.504	" "
0.449	6	18.0	0.333	Interface.
0.508	-6	29.8	-0.201	Flow upwards.
0.524	-6	36.4	-0.165	" "
0.545	-6	38.2	-0.157	" "
0.566	-6	77.0	-0.078	Surface.

Table: 1 - V - 10

Time since test started: 11 Hours

Position from Bed. Ft.	Distance Travelled. Inches	Time Taken. Secs.	Velocity Inch/Sec.	Remarks
0.000	-	-	0.000	Bed.
0.042	12	24.5	0.490	Flow downwards.
0.083	12	23.8	0.504	" "
0.167	12	19.5	0.616	" "
0.463	12	31.4	0.383	" "
0.507	-6	41.4	-0.145	Flow upwards.
0.523	-6	31.0	-0.195	" "
0.544	-6	35.0	-0.172	" "
0.565	-6	50.0	-0.120	" "

SALINITY CONCENTRATION MEASUREMENT

*Table: 1 - S - 2

Time since test started: 2 Hours

Section.	Bed Reading. Ft.	Depth Reading. Ft.	Depth. Ft.	Ω	c %	Remarks
2	1.101	1.201	0.100	7.1	0.355	Near bed.
		1.301	0.200	7.1	0.355	
		1.401	0.300	7.1	0.355	
		1.501	0.400	7.1	0.355	
		1.588	0.487	4.7	0.180	Near interface.
		1.660	0.559	0.0	0.000	Near top.
† 3	1.270	1.370	0.100	8.6	0.620	Near bed.
		1.470	0.200	8.6	0.620	
		1.570	0.300	8.6	0.620	
		1.670	0.400	8.2	0.560	
		1.770	0.500	0.7	0.030	
		1.841	0.571	0.0	0.000	Near top.
4	1.253	1.353	0.100	5.1	0.325	Near bed.
		1.453	0.200	5.1	0.325	
		1.553	0.300	5.1	0.325	
		1.658	0.405	2.8	0.145	Near interface.
		1.753	0.500	0.2	0.010	
		1.823	0.570	0.0	0.000	Near top.
5	1.397	1.497	0.100	5.6	0.340	Near bed.
		1.597	0.200	5.6	0.340	
		1.697	0.300	5.6	0.340	
		1.797	0.400	0.1	0.005	
		1.897	0.500	0.0	0.000	
		1.972	0.575	0.0	0.000	Near top.
6	1.292	1.392	0.100	6.1	0.380	Near bed.
		1.492	0.200	6.1	0.380	
		1.592	0.300	6.1	0.380	
		1.697	0.405	0.6	0.025	
		1.792	0.500	0.3	0.013	
		1.870	0.578	0.0	0.000	Near top.

*No salinity observations were made after the first hour of the test.

† Channel No. 3 was not working properly. It was rebalanced and range set again.

Table: 1 - S - 3

Time since test started: 3 Hours

Section	Bed Reading. Ft.	Depth Reading. Ft.	Depth Ft.	Ω	c %	Remarks
2	1.101	1.201	0.100	6.70	0.315	Near bed.
		1.301	0.200	6.70	0.315	
		1.401	0.300	6.70	0.315	
		1.501	0.400	6.70	0.315	
		1.601	0.500	6.70	0.315	
		1.659	0.558	4.15	0.150	Near top.
3	1.270	1.370	0.100	7.60	0.380	Near bed.
		1.470	0.200	7.60	0.380	
		1.570	0.300	7.60	0.380	
		1.670	0.400	7.60	0.380	
		1.770	0.500	1.10	0.045	
		1.828	0.558	0.00	0.000	Near top.
4	1.253	1.353	0.100	4.70	0.290	Near bed.
		1.453	0.200	4.70	0.290	
		1.553	0.300	4.70	0.290	
		1.653	0.400	4.60	0.280	
		1.753	0.500	0.30	0.015	
		1.822	0.569	0.00	0.000	Near top.
5	1.397	1.497	0.100	5.30	0.310	Near bed.
		1.597	0.200	5.30	0.310	
		1.697	0.300	5.30	0.310	
		1.797	0.400	0.50	0.020	
		1.897	0.500	0.00	0.000	
		1.961	0.564	0.00	0.000	Near top.
6	1.292	1.392	0.100	5.40	0.310	Near bed.
		1.492	0.200	5.40	0.310	
		1.592	0.300	5.40	0.310	
		1.692	0.400	1.60	0.070	
		1.792	0.500	0.40	0.015	
		1.862	0.570	0.00	0.000	Near top.

Table: 1 - S - 4

Time since test started: 4 Hours

Section	Bed Reading. Ft.	Depth Reading. Ft.	Depth Ft.	Ω	c %	Remarks
2	1.101	1.201	0.100	6.60	0.305	Near bed.
		1.301	0.200	6.60	0.305	
		1.401	0.300	6.60	0.305	
		1.501	0.400	6.60	0.305	
		1.601	0.500	6.50	0.295	
		1.657	0.556	5.20	0.205	Near top.
3	1.270	1.370	0.100	7.10	0.430	Near bed.
		1.470	0.200	7.10	0.430	
		1.570	0.300	7.10	0.430	
		1.670	0.400	6.70	0.390	
		1.770	0.500	1.40	0.055	
		1.826	0.556	0.00	0.00	Near top.
4	1.253	1.353	0.100	4.50	0.270	Near bed.
		1.453	0.200	4.50	0.270	
		1.553	0.300	4.50	0.270	
		1.653	0.400	4.30	0.255	
		1.753	0.500	0.10	0.005	
		1.820	0.567	0.00	0.000	Near top.
5	1.397	1.497	0.100	5.10	0.290	Near bed.
		1.597	0.200	5.10	0.290	
		1.697	0.300	5.00	0.280	
		1.797	0.400	0.20	0.010	
		1.897	0.500	0.00	0.000	
		1.959	0.562	0.00	0.000	Near top.
6	1.292	1.392	0.100	5.10	0.285	Near bed.
		1.492	0.200	5.10	0.285	
		1.592	0.300	5.10	0.285	
		1.692	0.400	4.60	0.245	
		1.792	0.500	0.50	0.020	
		1.869	0.577	0.00	0.000	Near top.

Table: 1 - S - 5

Time since test started: 5 Hours

Section	Bed Reading. Ft.	Depth Reading. Ft.	Depth Ft.	Ω	c %	Remarks
2	1.101	1.201	0.100	6.60	0.305	Near bed.
		1.301	0.200	6.60	0.305	
		1.401	0.300	6.60	0.305	
		1.501	0.400	6.60	0.305	Near interface.
		1.657	0.556	5.00	0.195	Near top.
3	1.270	1.370	0.100	7.10	0.430	Near bed.
		1.470	0.200	7.10	0.430	
		1.570	0.300	7.10	0.430	
		1.670	0.400	7.10	0.430	Near interface.
		1.788	0.518	2.00	0.080	
		1.831	0.561	0.00	0.000	Near top.
4	1.253	1.353	0.100	4.60	0.280	Near bed.
		1.453	0.200	4.60	0.280	
		1.553	0.300	4.60	0.280	
		1.653	0.400	4.60	0.280	
		1.713	0.460	2.20	0.110	Near interface.
		1.821	0.568	0.00	0.000	Near top.
5	1.397	1.497	0.100	5.10	0.290	Near bed.
		1.597	0.200	5.10	0.290	
		1.697	0.300	5.10	0.290	
		1.797	0.400	3.10	0.145	
		1.895	0.498	2.20	0.095	Near interface.
		1.958	0.561	0.00	0.000	Near top.
6	1.292	1.392	0.100	5.10	0.285	Near bed.
		1.492	0.200	5.10	0.285	
		1.592	0.300	5.10	0.285	
		1.692	0.400	5.10	0.285	Near interface.
		1.867	0.575	0.00	0.000	Near top.

Table: 1 - S - 6

Time since test started: 7 Hours

Section	Bed Reading. Ft.	Depth Reading. Ft.	Depth. . Ft.		c %	Remarks
2	1.101	1.201	0.100	6.40	0.290	Near bed.
		1.301	0.200	6.40	0.290	
		1.401	0.300	6.40	0.290	
		1.501	0.400	6.40	0.290	
		1.601	0.500	6.40	0.290	
		1.658	0.557	4.70	0.180	Near top.
3	1.270	1.370	0.100	6.60	0.380	Near bed.
		1.470	0.200	6.60	0.380	
		1.570	0.300	6.60	0.380	
		1.670	0.400	6.60	0.380	
		1.770	0.500	6.50	0.370	
		1.829	0.559	1.80	0.075	Near top.
4	1.253	1.353	0.100	4.30	0.255	Near bed.
		1.453	0.200	4.30	0.255	
		1.553	0.300	4.30	0.255	
		1.653	0.400	4.30	0.255	
		1.730	0.477	1.50	0.073	Near interface
		1.753	0.500	0.10	0.005	
		1.819	0.566	0.00	0.000	Near top.
5	1.397	1.497	0.100	4.70	0.253	Near bed.
		1.597	0.200	4.70	0.253	
		1.697	0.300	4.70	0.253	
		1.797	0.400	4.00	0.200	
		1.807	0.410	2.30	0.100	Near interface
		1.897	0.500	0.10	0.005	
		1.956	0.559	0.00	0.000	Near top.
6	1.292	1.392	0.100	5.00	0.275	Near bed.
		1.492	0.200	5.00	0.275	
		1.592	0.300	5.00	0.275	
		1.692	0.400	4.90	0.270	
		1.792	0.500	1.10	0.045	
		1.866	0.574	0.00	0.000	Near top.

Table: 1 - S - 7

Time since test started: 8 Hours

Section.	Bed Reading. Ft.	Depth Reading. Ft.	Depth. Ft.	Ω	c %	Remarks
2	1.101	1.201	0.100	6.50	0.295	Near bed.
		1.301	0.200	6.50	0.295	
		1.501	0.400	6.50	0.295	
		1.601	0.500	6.40	0.290	
		1.653	0.552	4.20	0.155	Near top.
3	1.270	0.370	0.100	6.70	0.390	Near bed.
		0.470	0.200	6.70	0.390	
		1.670	0.400	6.70	0.390	
		1.770	0.500	6.60	0.380	
		1.828	0.558	2.50	0.110	Near top.
4	1.253	1.353	0.100	4.00	0.230	Near bed.
		1.453	0.200	4.00	0.230	
		1.653	0.400	4.00	0.230	
		1.744	0.491	1.90	0.095	Near interface.
		1.819	0.566	0.00	0.000	Near top.
5	1.397	1.497	0.100	4.70	0.253	Near bed.
		1.597	0.200	4.70	0.253	
		1.797	0.400	4.50	0.235	
		1.812	0.415	3.20	0.145	Near interface.
		1.950	0.553	0.00	0.000	Near top.
6	1.292	1.392	0.100	5.00	0.275	Near bed.
		1.492	0.200	5.00	0.275	
		1.692	0.400	4.90	0.270	
		1.792	0.500	2.00	0.090	
		1.665	0.573	0.30	0.012	Near top.

Table: 1 - S - 8

Time since test started: 9 Hours

Section	Bed Reading. Ft.	Depth Reading. Ft.	Depth. Ft.	Ω	c %	Remarks
2	1.101	1.201	0.100	6.30	0.280	Near bed.
		1.301	0.200	6.30	0.280	
		1.401	0.300	6.30	0.280	
		1.501	0.400	6.30	0.280	
		1.601	0.500	6.20	0.275	
		1.653	0.552	4.10	0.150	Near top.
3	1.270	1.370	0.100	6.60	0.380	Near bed.
		1.470	0.200	6.60	0.380	
		1.570	0.300	6.60	0.380	
		1.670	0.400	6.60	0.380	
		1.770	0.500	6.40	0.360	
		1.827	0.557	1.40	0.055	Near top.
4	1.253	1.353	0.100	4.20	0.245	Near bed.
		1.453	0.200	4.20	0.245	
		1.553	0.300	4.20	0.245	
		1.653	0.400	4.20	0.245	
		1.753	0.500	3.60	0.200	Near interface.
		1.767	0.514	2.20	0.110	
		1.818	0.565	0.00	0.000	Near top.
5	1.397	1.497	0.100	4.50	0.235	Near bed.
		1.597	0.200	4.50	0.235	
		1.697	0.300	4.50	0.235	
		1.797	0.400	4.30	0.220	
		1.825	0.428	1.90	0.080	Near interface.
		1.897	0.500	0.20	0.010	
		1.949	0.552	0.00	0.000	Near top.
6	1.292	1.392	0.100	4.80	0.260	Near bed.
		1.492	0.200	4.80	0.260	
		1.592	0.300	4.80	0.260	
		1.692	0.400	4.70	0.250	
		1.742	0.450	3.00	0.140	Near interface.
		1.792	0.500	1.20	0.050	
		1.863	0.571	0.10	0.003	Near top.

Table: 1 - S - 9

Time since test started: 10 Hours

Section	Bed Reading. Ft.	Depth Reading. Ft.	Depth Ft.	Ω	c %	Remarks
2	1.101	1.201	0.100	6.30	0.280	Near bed.
		1.401	0.300	6.30	0.280	
		1.501	0.400	6.30	0.280	
		1.601	0.500	6.20	0.275	
		1.652	0.551	4.10	0.150	Near top.
3	1.270	1.370	0.100	6.50	0.370	Near bed.
		1.570	0.300	6.50	0.370	
		1.670	0.400	6.50	0.370	
		1.770	0.500	6.40	0.360	
		1.823	0.553	3.10	0.135	Near top.
4	0.253	1.353	0.100	4.00	0.230	Near bed.
		1.553	0.300	4.00	0.230	
		1.653	0.400	4.00	0.230	
		1.753	0.500	3.90	0.220	
		1.817	0.564	0.80	0.040	Near top.
5	1.397	1.497	0.100	4.40	0.230	Near bed.
		1.697	0.300	4.40	0.230	
		1.797	0.400	4.40	0.230	
		1.828	0.431	3.00	0.135	Near interface.
		1.897	0.500	0.10	0.005	
		1.947	0.550	0.00	0.000	Near top.
6	1.292	1.392	0.100	4.80	0.260	Near bed.
		1.592	0.300	4.80	0.260	
		1.692	0.400	4.80	0.260	
		1.742	0.450	2.60	0.120	Near interface.
		1.792	0.500	1.40	0.060	
		1.862	0.570	0.20	0.015	Near top.

Table: 1 - S - 10

Time since test started: 11 Hours

Section	Bed Reading. Ft.	Depth Reading. Ft.	Depth Ft.	Ω	c %	Remarks
2	1.101	1.201	0.100	6.20	0.275	Near bed.
		1.301	0.200	6.20	0.275	
		1.401	0.300	6.20	0.275	
		1.501	0.400	6.20	0.275	
		1.601	0.500	6.10	0.270	
		1.652	0.551	4.20	0.155	Near top.
3	1.270	1.370	0.100	6.10	0.330	Near bed.
		1.470	0.200	6.10	0.330	
		1.570	0.300	6.10	0.330	
		1.670	0.400	6.10	0.330	
		1.770	0.500	6.10	0.330	
		1.822	0.552	3.30	0.145	Near top.
4	0.253	1.353	0.100	3.90	0.225	Near bed.
		1.453	0.200	3.90	0.225	
		1.553	0.300	3.90	0.225	
		1.653	0.400	3.90	0.225	
		1.753	0.500	3.80	0.215	
		1.814	0.561	1.70	0.085	Near top.
5	0.397	1.497	0.100	4.40	0.230	Near bed.
		1.597	0.200	4.40	0.230	
		1.697	0.300	4.40	0.230	
		1.837	0.440	3.60	0.170	Near interface.
		1.897	0.500	0.30	0.012	
		1.946	0.549	0.00	0.000	Near top.
6	1.292	1.392	0.100	4.70	0.255	Near bed.
		1.492	0.200	4.70	0.255	
		1.592	0.300	4.70	0.255	
		1.692	0.400	4.70	0.255	
		1.792	0.500	1.20	0.050	
		1.862	0.570	0.40	0.025	Near top.

TEST RUN 2

General Data

Material Used: Salt

Dye Used: Flouresene

Flume: Level

Sluice Gate Opening: 4"

Test Started: 11:45 A.M. on 29.7.64

Duration of Test: 12 Hours

Observation Time: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 and 11 hours after the test started.

Data of Conductivity Probes

Conductivity Probe No.	Attenuator Reading.	Range Set.	Used at Section.	Bed Reading Ft.
2.	x20	0 to 1% salinity concentration by weight	2	1.102
3.	x100		3	1.276
4.	x200		4	1.254
5.	x200		5	1.397
6.	x200		6	1.344

Flow Data

Flow over weir - Free

Gauge reading upstream of weir = 0.930 Ft.

Reading for no flow = 0.589 Ft.

∴ Head over weir = 0.341 Ft.

From flow curve for free flowing weir (Appendix A)

Q = 0.097 C.F.S.

PROFILE MEASUREMENTS

Test Run: 2

Table: 2 - P - 1

Time since test started: 1 Hour .

Section.	Bed Reading. Ft.	Density Layer Reading. Ft.	*Top Reading. Ft.	d Col. 3- Col. 2 Ft.	D Col. 4- Col. 2 Ft.	λ_1	C_0 %	H Ft.
1	2	3	4	5	6	7	8	9
1	0.072	-	0.679	-	0.607	•		
2	0.236	0.592	0.825	0.356	0.589	10	1.00	0.341
3	0.071	0.419	0.668	0.348	0.597			
4	0.104	0.436	0.706	0.332	0.602			
5	0.122	0.423	0.725	0.301	0.603	T = 72°F		
6	0.098	-	0.706	-	0.608			

Where d = Thickness of density layer in feet.

D = Total depth of flow in feet.

λ_1 = Deflection of recorder for water flow over weir.

λ = Deflection of recorder.

C_0 = Concentration percent by weight, taken from λ - c plot of the probe used.

H = Head over weir in feet .

*Top readings went on decreasing consistently throughout the test, because there was a leakage from the pump at the tail end of the flume.

•Probe No. 2 was used. Refer Appendix B for its calibration curve.

NOTE: These signs will have the same interpretation throughout all profile measurements.

Table: 2 - P - 2

Time since test started: 2 Hours .

Section.	Bed Reading. Ft.	Density Layer Reading. Ft.	*Top Reading. Ft.	d Col. 3- Col. 2 Ft.	D Col. 4- Col. 2 Ft.	Λ_1	C_0 %	H Ft.
1	2.	3	4	5	6	7	8	9
1	0.072	-	0.678	-	0.606			
2	0.236	0.626	0.823	0.390	0.587	9.8	0.90	0.341
3	0.071	0.455	0.670	0.384	0.599			
4	0.104	0.464	0.705	0.360	0.601			
5	0.122	0.453	0.725	0.331	0.603	T = 72°F		
6	0.098	-	0.705	-	0.607			

Table: 2 - P - 3

Time since test started: 3 Hours .

1	0.072	-	0.677	-	0.605			
2	0.236	0.646	0.823	0.410	0.587	9.7	0.87	0.341
3	0.071	0.477	0.669	0.406	0.598			
4	0.104	0.486	0.704	0.382	0.600			
5	0.122	0.476	0.725	0.354	0.603	T = 72°F		
6	0.098	-	0.704	-	0.606			

Table: 2 - P - 4

Time since test started: 4 Hours .

1	0.072	-	0.677	-	0.605			
2	0.236	0.666	0.822	0.430	0.586	9.7	0.87	0.341
3	0.071	0.494	0.669	0.423	0.598			
4	0.104	0.505	0.704	0.401	0.600			
5	0.122	0.490	0.725	0.368	0.603	T = 73°F		
6	0.098	-	0.704	-	0.606			

Table: 2 - P - 5

Time since test started: 5 Hours.

Section.	Bed Reading. Ft.	Density Layer Reading. Ft.	*Top Reading. Ft.	d Col. 3- Col. 2 Ft.	D Col. 4- Col. 2 Ft.	Ω_1	C_0 %	H Ft.
1	2	3	4	5	6	7	8	9
1	0.072	-	0.675	-	0.603	•		
2	0.236	0.682	0.820	0.446	0.584	9.6	0.825	0.341
3	0.071	0.509	0.666	0.438	0.595			
4	0.104	0.520	0.702	0.416	0.598			
5	0.122	0.507	0.723	0.385	0.601	T = 73°F		
6	0.098	-	0.702	-	0.604			

Table: 2 - P - 6

Time since test started: 6 Hours .

1	0.072	-	0.674	-	0.602	•		
2	0.236	0.694	0.819	0.458	0.583	9.6	0.825	0.341
3	0.071	0.520	0.667	0.449	0.596			
4	0.104	0.531	0.710	0.427	0.606			
5	0.122	0.521	0.722	0.399	0.600	T = 73.5°F		
6	0.098	-	0.701	-	0.603			

Table: 2 - P - 7

Time since test started: 7 Hours .

1	0.072	-	0.672	-	0.600	•		
2	0.236	0.704	0.817	0.468	0.581	9.5	0.800	0.341
3.	0.071	0.530	0.665	0.459	0.594			
4	0.104	0.541	0.697	0.437	0.593			
5	0.122	0.527	0.721	0.405	0.599	T = 74°F		
6	0.098	-	0.700	-	0.602			

Table: 2 - P - 8

Time since test started: 8 Hours.

Section.	Bed Reading. Ft.	Density Layer Reading. Ft.	*Top Reading. Ft.	d Col. 3- Col. 2 Ft.	D Col. 4- Col. 2 Ft.	Λ_1	C_0 %	H Ft.
1	2	3	4	5	6	7	8	9
1	0.072	-	0.672	-	0.600			
2	0.236	0.714	0.817	0.478	0.581	9.5	0.800	0.341
3	0.071	0.540	0.664	0.469	0.593			
4	0.104	0.548	0.698	0.444	0.594			
5	0.122	0.534	0.718	0.412	0.596	T = 74°F		
6	0.098	-	0.699	-	0.601			

Table: 2 - P - 9

Time since test started: 9 Hours.

1	0.072	-	0.670	-	0.598			
2	0.236	0.726	0.815	0.490	0.579	9.45	0.780	0.341
3	0.071	0.548	0.663	0.477	0.592			
4	0.104	0.557	0.698	0.453	0.594			
5	0.122	0.539	0.717	0.417	0.595	T = 75°F		
6	0.098	-	0.698	-	0.600			

Table: 2 - P - 10

Time since test started: 10 Hours.

1	0.072	-	0.670	-	0.598			
2	0.236	0.735	0.815	0.499	0.579	9.40	0.770	0.340
3	0.071	0.556	0.662	0.485	0.591			
4	0.104	0.564	0.697	0.460	0.593			
5	0.122	0.540	0.716	0.418	0.594	T = 75°F		
6	0.098	-	0.696	-	0.598			

Table: 2 - P - 11

Time since test started: 11 Hours .

Section	Bed Reading. Ft.	Density Layer Reading. Ft.	*Top Reading. Ft.	d Col. 3- Col. 2 Ft.	D Col. 4- Col. 2 Ft.	Λ_1	C_0 %	H Ft.
1	2	3	4	5	6	7	8	9
1	0.072	-	0.666	-	0.594			
2	0.236	0.745	0.810	0.509	0.574	9.35	0.760	0.339
3	0.071	0.562	0.660	0.491	0.589			
4	0.104	0.567	0.695	0.463	0.591			
5	0.122	0.544	0.716	0.422	0.594	T= 75°F		
6	0.098	-	0.696	-	0.598			

VELOCITY MEASUREMENTS

Test Run 2

Section of observation: 5

Distance from upstream sluice gate: 85 Feet.

Table: 2 - V - 1

Time since test started: 1 Hour .

Position From Bed. Ft.	Distance Travelled. Inches	Time Taken. Secs.	Velocity Inch/Sec.	Remarks.
0.005	2	29.3	0.068	Near bed.
0.021	3	23.4	0.128	
0.167	12	9.2	1.305	
0.420	-3	21.0	-0.143	
0.603	-3	36.0	-0.083	Near surface.

Table: 2 - V - 2

Time since test started: 2 Hours.

Position From Bed. Ft.	Distance Travelled. Inches	Time Taken. Secs.	Velocity Inch/Sec.	Remarks.
0.010	6	41.0	0.147	Near bed.
0.020	4	22.4	0.179	
0.083	6	5.6	1.070	
0.167	12	8.5	1.410	
0.437	-2	13.6	-0.147	
0.603	-2.5	34.0	-0.073	Near top.

Table: 2 - V - 3

Time since test started: 3 Hours.

Position From Bed. Ft.	Distance Travelled. Inches	Time Taken. Secs.	Velocity Inch/Sec.	Remarks.
0.010	12	59.2	0.203	Near bed
0.125	12	9.7	1.237	
0.250	12	9.0	1.334	
0.354	6	13.0	0.462	
0.478	6	18.0	0.333	
0.479	-4	20.0	-0.200	
0.520	-3	15.6	-0.257	
0.603	-4	15.6	-0.192	Near top.

Table: 2 - V - 4

Time since test started: 4 Hours.

Position From Bed. Ft.	Distance Travelled. Inches	Time Taken. Secs.	Velocity Inch/Sec.	Remarks.
0.010	6	24.2	0.248	Near bed.
0.062	10	12.5	0.800	
0.083	9	8.0	1.125	
0.243	12	9.8	1.225	
0.368	12	15.5	0.774	
0.436	-4	16.2	-0.247	
0.520	-7	33.2	-0.211	
0.603	-3	28.7	-0.104	Near top.

Table: 2 - V - 5

Time since test started: 5 Hours .

Position From Bed. Ft.	Distance Travelled. Inches	Time Taken. Secs.	Velocity . Inch/Sec.	Remarks .
0.021	12	43.0	0.279	Near bed .
0.042	12	31.5	0.381	
0.125	12	10.0	1.200	
0.302	6	5.5	1.090	
0.385	12	18.5	0.648	
0.434	-3	16.5	-0.182	
0.518	-3	13.2	-0.227	
0.538	-2	10.0	-0.200	
0.559	-3	17.0	-0.177	
0.601	-3	18.5	-0.162	Near top.

Table: 2 - V - 6

Time since test started: 6 Hours .

Position From Bed. Ft.	Distance Travelled. Inches	Time Taken. Secs.	Velocity . Inch/Sec.	Remarks .
0.010	6	25.8	0.233	Near bed .
0.062	10	15.0	0.667	
0.274	12	11.8	1.017	
0.399	12	58.3	0.206	
0.517	-6	42.8	-0.140	
0.600	-3	48.0	-0.062	Near top .

Table: 2 - V - 7

Time since test started: 7 Hours .

Position From Bed . Ft.	Distance Travelled. Inches	Time Taken. Secs.	Velocity . Inch/Sec.	Remarks .
0.010	3	28.9	0.100	Near bed .
0.021	6	16.8	0.357	
0.042	6	13.2	0.454	
0.083	2	2.2	0.910	
0.342	12	16.2	0.740	
0.405	12	41.4	0.290	
0.516	-3	24.2	-0.124	
0.557	-6	21.8	-0.275	
0.599	-3	29.0	-0.603	Near top .

Table: 2 - V - 8

Time since test started: 8 Hours .

Position From Bed . Ft.	Distance Travelled. Inches	Time Taken. Secs.	Velocity . Inch/Sec.	Remarks .
0.010	3	15.5	0.194	Near bed .
0.042	6	10.5	0.572	
0.062	12	11.5	1.044	
0.125	12	14.0	0.857	
0.412	12	26.0	0.462	
0.471	3	12.2	0.246	
0.492	-3	14.0	-0.214	
0.575	-3	14.8	-0.203	
0.596	-3	25.8	-0.116	Near top .

Table: 2 - V - 9

Time since test started: 9 Hours .

Position From Bed . Ft.	Distance Travelled. Inches	Time Taken. Secs.	Velocity . Inch/Sec.	Remarks .
0.021	3	23.5	0.128	Near bed .
0.125	6	6.7	0.895	
0.354	6	5.7	1.053	
0.417	8	22.6	0.354	
0.470	-3	12.3	-0.244	
0.553	-3	15.8	-0.190	
0.595	-3	-19.5	-0.154	Near top .

Table: 2 - V - 10

Time since test started: 10 Hours .

Position From Bed . Ft.	Distance Travelled. Inches	Time Taken. Secs.	Velocity . Inch/Sec.	Remarks .
0.005	2	44.2	0.045	Near bed .
0.208	6	10.7	0.561	
0.293	6	7.0	0.857	
0.418	6	14.2	0.422	
0.511	-2	15.3	-0.131	
0.552	-3	22.0	-0.136	
0.594	-3	24.3	-0.123	Near top .

Table: 2 - V - 11

Time since test started: 11 Hours .

Position From Bed . Ft.	Distance Travelled. Inches	Time Taken . Secs.	Velocity . Inch/Sec.	Remarks .
0.010	3	13.4	0.224	Near bed .
0.062	6	11.2	0.536	
0.083	5	6.8	0.735	
0.167	6	6.0	1.000	
0.422	6	12.0	0.500	
0.511	-3	17.0	-0.177	
0.573	-3	14.0	-0.214	
0.594	-3	15.0	-0.200	Near top .

Table: 2 - S - 1

Time since test started: 1 Hour .

Section	Bed Reading . Ft.	Depth Reading . Ft.	Depth Ft.	Λ	c %	Remarks
2	1.102	1.202	0.100	10.10	1.000	Near bed .
		1.302	0.200	10.10	1.000	
		1.402	0.300	10.10	1.000	
		1.472	0.370	4.40	0.165	Near interface.
		1.502	0.400	0.30	0.008	
		1.602	0.500	0.20	0.004	Near top .
		1.691	0.589	0.00	0.000	
3	1.276	1.376	0.100	10.10	1.000	Near bed .
		1.476	0.200	10.10	1.000	
		1.576	0.300	10.10	1.000	
		1.619	0.343	1.40	0.055	Near interface
		1.676	0.400	0.40	0.015	
		1.776	0.500	0.30	0.010	
		1.870	0.594	0.00	0.000	Near top .
4	1.254	1.354	0.100	10.20	1.000	Near bed .
		1.454	0.200	10.20	1.000	
		1.554	0.300	10.20	1.000	
		1.584	0.330	2.80	0.145	Near interface
		1.654	0.400	0.25	0.013	
		1.754	0.500	0.20	0.010	
		1.856	0.602	0.00	0.00	Near top .
5	1.397	1.497	0.100	10.20	1.000	Near bed .
		1.597	0.200	10.20	1.000	
		1.697	0.300	2.00	0.085	
		1.697	0.400	0.55	0.025	Near interface
		1.897	0.500	0.50	0.020	
		1.994	0.597	0.20	0.008	Near top
6	1.344	1.444	0.100	10.20	1.000	Near bed .
		1.544	0.200	10.20	1.000	
		1.644	0.300	2.50	0.110	Near interface
		1.744	0.400	0.40	0.015	
		1.844	0.500	0.30	0.010	
		1.952	0.608	0.00	0.000	Near top .

Table: 2 - S - 2

Time since test started: 2 Hours.

Section.	Bed Reading. Ft.	Depth Reading. Ft.	Depth Ft.	Ω	c %	Remarks
2	1.102	1.202	0.100	10.10	1.000	Near bed.
		1.402	0.300	10.10	1.000	
		1.496	0.396	9.40	0.770	Near interface
		1.602	0.500	0.20	0.004	
		1.689	0.587	0.00	0.000	Near top.
3	1.276	1.376	0.100	10.10	1.000	Near bed.
		1.576	0.300	10.10	1.000	
		1.653	0.377	2.60	0.110	Near interface
		1.776	0.500	0.35	0.013	
		1.870	0.594	0.00	0.000	Near top.
4	1.254	1.354	0.100	10.20	1.000	Near bed.
		1.554	0.300	10.20	1.000	
		1.604	0.350	7.90	0.630	Near interface
		1.754	0.500	0.20	0.010	
		1.854	0.600	0.00	0.000	Near top.
5	1.397	1.497	0.100	10.20	1.000	Near bed.
		1.697	0.300	10.20	1.000	
		1.715	0.318	7.80	0.580	Near interface
		1.897	0.500	0.90	0.035	
		1.988	0.591	0.30	0.010	Near top.
6	1.344	1.444	0.100	10.20	1.000	Near bed.
		1.644	0.300	10.20	1.000	
		1.744	0.400	1.30	0.050	Near interface
		1.844	0.500	0.70	0.030	
		1.950	0.606	0.15	0.005	Near top.

Table: 2 - S - 3

Time since test started: 3 Hours.

Section	Bed Reading. Ft.	Depth Reading. Ft.	Depth Ft.	Ω	c %	Remarks
2	1.102	1.202	0.100	10.10	1.000	Near bed.
		1.402	0.300	10.10	1.000	
		1.516	0.412	9.80	0.900	Near interface
		1.602	0.500	0.35	0.010	
		1.689	0.587	0.20	0.004	Near top.
3	1.276	1.376	0.100	10.10	1.000	Near bed.
		1.576	0.300	10.10	1.000	
		1.671	0.395	1.70	0.070	Near interface
		1.776	0.500	0.50	0.020	
		1.863	0.587	0.15	0.005	Near top.
4	1.254	1.354	0.100	10.20	1.000	Near bed.
		1.554	0.300	10.20	1.000	
		1.631	0.377	4.00	0.230	Near interface
		1.754	0.500	0.30	0.015	
		1.854	0.600	0.00	0.000	Near top.
5	1.397	1.497	0.100	10.20	1.000	Near bed.
		1.697	0.300	10.20	1.000	
		1.737	0.340	8.80	0.725	Near interface
		1.897	0.500	1.80	0.075	
		1.988	0.591	0.60	0.025	Near top.
6	1.344	1.444	0.100	10.20	1.000	Near bed.
		1.644	0.300	10.20	1.000	
		1.674	0.330	10.20	1.000	
		1.684	0.340	7.20	0.500	Near interface
		1.844	0.500	1.30	0.055	
		1.950	0.606	0.30	0.010	Near top.

Table: 2 - S - 4

Time since test started: 4 Hours.

Section	Bed Reading. Ft.	Depth Reading. Ft.	Depth Ft.	Ω	c %	Remarks
2	1.102	1.202	0.100	10.10	1.000	Near bed.
		1.402	0.300	10.10	1.000	
		1.537	0.435	4.70	0.180	Near interface
		1.602	0.500	0.35	0.120	
		1.688	0.586	0.20	0.004	Near top.
3	1.276	1.376	0.100	10.10	1.000	Near bed.
		1.576	0.300	10.10	1.000	
		1.684	0.408	4.50	0.215	Near interface
		1.776	0.500	0.45	0.015	
		1.864	0.588	0.15	0.006	Near top.
4	1.254	1.354	0.100	10.20	1.000	Near bed.
		1.554	0.300	10.20	1.000	
		1.653	0.399	1.60	0.080	Near interface
		1.754	0.500	0.45	0.025	
		1.853	0.599	0.00	0.000	Near top.
5	1.397	1.497	0.100	10.20	1.000	Near bed.
		1.697	0.300	10.20	1.000	
		1.754	0.357	9.80	0.910	Near interface
		1.897	0.500	2.00	0.085	
		1.988	0.591	0.55	0.025	Near top.
6	1.344	1.444	0.100	10.20	1.000	Near bed.
		1.644	0.300	10.20	1.000	
		1.695	0.351	9.60	0.860	Near interface.
		1.844	0.500	1.60	0.065	
		1.950	0.606	0.35	0.015	Near top.

Table: 2 - S - 5

Time since test started: 5 Hours.

Section	Bed Reading. Ft.	Depth Reading. Ft.	Depth Ft.	Λ	c %	Remarks
2	1.102	1.202	0.100	10.10	1.000	Near bed.
		1.402	0.300	10.10	1.000	
		1.502	0.400	10.10	1.000	
		1.548	0.446	8.20	0.510	Near interface
		1.602	0.500	0.55	0.230	
		1.686	0.584	0.30	0.008	Near top.
3	1.276	1.376	0.100	10.10	1.000	Near bed.
		1.576	0.300	10.10	1.000	
		1.676	0.400	10.10	1.000	
		1.705	0.429	1.60	0.065	Near interface
		1.776	0.500	0.65	0.025	
		1.863	0.587	0.20	0.007	Near top.
4	1.254	1.354	0.100	10.20	1.000	Near bed.
		1.554	0.300	10.20	1.000	
		1.654	0.400	7.00	0.520	
		1.668	0.414	1.60	0.080	Near interface
		1.754	0.500	0.75	0.035	
		1.849	0.595	0.20	0.010	Near top.
5	1.397	1.497	0.100	10.20	1.000	Near bed.
		1.697	0.300	10.20	1.000	
		1.764	0.367	10.20	1.000	
		1.897	0.500	3.10	0.145	
		1.986	0.589	1.40	0.055	Near top.
6	1.344	1.444	0.100	10.20	1.000	Near bed.
		1.644	0.300	10.20	1.000	
		1.706	0.362	9.50	0.850	
		1.710	0.366	9.00	0.750	Near interface
		1.844	0.500	3.00	0.140	
		1.948	0.604	0.70	0.030	Near top.

Table: 2 - S - 6

Time since test started: 6 Hours .

Section	Bed Reading. Ft.	Depth Reading. Ft.	Depth Ft.	Ω	c %	Remarks
2	1.102	1.202	0.100	10.10	1.000	Near bed .
		1.402	0.300	10.10	1.000	
		1.565	0.463	5.20	0.210	Near interface
		1.602	0.500	0.55	0.015	
		1.685	0.583	0.35	0.010	Near top.
3	1.276	1.376	0.100	10.10	1.000	Near bed .
		1.576	0.300	10.10	1.000	
		1.717	0.441	2.10	0.090	Near interface
		1.776	0.500	0.60	0.025	
		1.864	0.588	0.10	0.005	Near top .
4	1.254	1.354	0.100	10.20	1.000	Near bed .
		1.554	0.300	10.20	1.000	
		1.675	0.421	3.80	0.215	Near interface
		1.754	0.500	0.90	0.045	
		1.850	0.596	0.40	0.020	Near top .
5	1.397	1.497	0.100	10.20	1.000	Near bed .
		1.697	0.300	10.20	1.000	
		1.777	0.380	9.60	0.870	Near interface
		1.897	0.500	3.45	0.165	
		1.985	0.588	1.50	0.060	Near top.
6	1.344	1.444	0.100	10.20	1.000	Near bed .
		1.644	0.300	10.20	1.000	
		1.722	0.378	6.40	0.410	Near interface
		1.844	0.500	3.30	0.155	
		1.947	0.603	0.60	0.025	Near top .

Table: 2 - S - 7

Time since test started: 7 Hours

Section	Bed Reading. Ft.	Depth Reading. Ft.	Depth Ft.	Ω	c %	Remarks
2	1.102	1.202	0.100	10.10	1.000	Near bed.
		1.402	0.300	10.10	1.000	
		1.502	0.400	10.10	1.000	
		1.576	0.474	5.70	0.240	Near interface
		1.602	0.500	1.00	0.030	
		1.683	0.581	0.40	0.010	Near top.
3	1.276	1.376	0.100	10.10	1.000	Near bed.
		1.576	0.300	10.10	1.000	
		1.676	0.400	10.10	1.000	
		1.727	0.451	2.70	0.115	Near interface
		1.776	0.500	1.00	0.040	
		1.862	0.586	0.20	0.007	Near top.
4	1.254	1.354	0.100	10.20	1.000	Near bed.
		1.554	0.300	10.20	1.000	
		1.654	0.400	10.20	1.000	
		1.688	0.434	2.60	0.135	Near interface
		1.754	0.500	1.40	0.070	
		1.847	0.593	0.40	0.020	Near top.
5	1.397	1.497	0.100	10.20	1.000	Near bed.
		1.697	0.300	10.20	1.000	
		1.787	0.390	8.80	0.725	Near interface
		1.847	0.450	5.30	0.310	
		1.897	0.500	4.80	0.260	
		1.985	0.588	1.80	0.075	Near top.
6	1.344	1.444	0.100	10.20	1.000	Near bed.
		1.644	0.300	10.20	1.000	
		1.734	0.390	5.80	0.350	Near interface
		1.844	0.500	5.00	0.275	
		1.946	0.602	0.85	0.035	Near top.

Table: 2 - S - 8

Time since test started: 8 Hours.

Section	Bed Reading. Ft.	Depth Reading. Ft.	Depth Ft.	Ω	c %	Remarks
2	1.102	1.202	0.100	10.10	1.000	Near bed.
		1.402	0.300	10.10	1.000	
		1.587	0.485	5.00	0.195	Near interface
		1.602	0.500	1.40	0.045	
		1.683	0.581	0.40	0.010	Near top.
3	1.276	1.376	0.100	10.10	1.000	Near bed.
		1.576	0.300	10.10	1.000	
		1.737	0.461	2.70	0.115	Near interface
		1.776	0.500	1.00	0.040	
		1.864	0.588	0.10	0.005	Near top.
4	1.254	1.354	0.100	10.20	1.000	Near bed.
		1.554	0.300	10.20	1.000	
		1.699	0.445	2.30	0.120	Near interface
		1.754	0.500	1.45	0.070	
		1.848	0.594	0.55	0.025	Near top.
5	1.397	1.497	0.100	10.20	1.000	Near bed.
		1.697	0.300	10.20	1.000	
		1.796	0.399	7.60	0.560	Near interface
		1.897	0.500	5.20	0.300	
		1.986	0.589	1.70	0.070	Near top.
6	1.344	1.444	0.100	10.20	1.000	Near bed.
		1.644	0.300	10.20	1.000	
		1.744	0.400	5.70	0.340	
		1.844	0.500	4.60	0.245	
		1.945	0.601	0.85	0.035	Near top.

Table: 2 - S - 9

Time since test started: 9 Hours .

Section	Bed Reading. Ft.	Depth Reading. Ft.	Depth Ft.	Ω	c %	Remarks
2	1.102	1.202	0.100	10.10	1.000	Near bed .
		1.402	0.300	10.10	1.000	
		1.502	0.400	10.10	1.000	
		1.598	0.496	5.20	0.210	Near interface
		1.602	0.500	3.50	0.125	
		1.681	0.579	0.45	0.015	Near top .
3	1.276	1.376	0.100	10.10	1.000	Near bed .
		1.576	0.300	10.10	1.000	
		1.676	0.400	10.10	1.000	
		1.746	0.470	3.30	0.147	Near interface
		1.776	0.500	1.80	0.073	
		1.862	0.586	0.30	0.010	Near top .
4	1.254	1.354	0.100	10.20	1.000	Near bed .
		1.554	0.300	10.20	1.000	
		1.654	0.400	10.20	1.000	
		1.710	0.456	3.00	0.160	Near interface
		1.754	0.500	2.00	0.100	
		1.845	0.591	0.80	0.035	Near top .
5	1.397	1.497	0.100	10.20	1.000	Near bed .
		1.697	0.300	10.20	1.000	
		1.797	0.400	9.00	0.760	
		1.847	0.450	7.00	0.485	Near interface
		1.897	0.500	6.40	0.420	
		1.981	0.584	2.50	0.110	Near top
6	1.344	1.444	0.100	10.20	1.000	Near bed .
		1.644	0.300	10.20	1.000	
		1.744	0.400	6.80	0.455	
		1.794	0.450	6.00	0.370	
		1.844	0.500	5.50	0.320	
		1.944	0.600	1.30	0.053	Near top .

Table: 2 - S - 10

Time since test started: 10 Hours .

Section	Bed Reading. Ft.	Depth Reading . Ft.	Depth Ft.	Ω	c %	Remarks
2	1.102	1.202	0.100	10.10	1.000	Near bed .
		1.402	0.300	10.10	1.000	
		1.609	0.507	4.50	0.170	Near interface
		1.652	0.550	1.30	0.040	
		1.681	0.579	0.60	0.017	Near top .
3	1.276	1.376	0.100	10.10	1.000	Near bed .
		1.576	0.300	10.10	1.000	
		1.747	0.471	4.70	0.230	Near interface
		1.826	0.550	1.70	0.070	
		1.860	0.584	0.35	0.015	Near top .
4	1.254	1.354	0.100	9.20	0.825	Near bed .
		1.554	0.300	9.20	0.825	
		1.710	0.456	2.80	0.145	Near interface
		1.804	0.550	1.90	0.075	
		1.839	0.585	1.10	0.050	Near top .
5	1.397	1.497	0.100	10.20	1.000	Near bed .
		1.697	0.300	10.20	1.000	
		1.797	0.400	10.10	0.980	Above interface
		1.947	0.550	5.60	0.335	
		1.982	0.585	2.50	0.110	Near top .
6	1.344	1.444	0.100	10.20	1.000	Near bed .
		1.644	0.300	10.20	1.000	
		1.744	0.400	6.50	0.420	Near interface
		1.894	0.550	4.00	0.200	
		1.942	0.598	1.05	0.045	Near top .

Table: 2 - S - 11

Time since test started: 11 Hours .

Section	Bed Reading . Ft.	Depth Reading . Ft.	Depth Ft.	Ω	c %	Remarks
2	1.102	1.202	0.100	10.10	1.000	Near bed .
		1.402	0.300	10.10	1.000	
		1.502	0.400	10.10	1.000	
		1.615	0.513	6.10	0.270	Near interface
		1.676	0.574	0.75	0.025	Near top .
3	1.276	1.376	0.100	10.10	1.000	Near bed .
		1.576	0.300	10.10	1.000	
		1.676	0.400	10.10	1.000	
		1.758	0.482	3.50	0.157	Near interface
		1.859	0.583	0.50	0.020	Near top .
4	1.254	1.354	0.100	9.60	0.890	Near bed .
		1.554	0.300	9.60	0.890	
		1.654	0.400	9.60	0.890	
		1.711	0.457	3.40	0.185	Near interface
		1.841	0.587	1.40	0.070	Near top .
5	1.397	1.497	0.100	10.20	1.000	Near bed .
		1.697	0.300	10.20	1.000	
		1.797	0.400	10.20	1.000	
		1.897	0.500	7.50	0.550	
		1.979	0.582	3.50	0.165	Near top .
6	1.344	1.444	0.100	10.20	1.000	Near bed .
		1.644	0.300	10.20	1.000	
		1.744	0.400	7.60	0.545	
		1.844	0.500	6.00	0.370	
		1.942	0.598	2.30	0.100	Near top .

Test Run 3

General Data.

Material Used: *Aluminium silicate

Flume: Level

Sluice Gate Opening: 5"

Test Started: 3:15 P.M. on 14.8.64

Duration of Test: 92 Hours

Observation Time: 2, 5, 7, 17, 27, 42, 53, 67, 72, 78, and 90 hours after the start of the test.

Data of Syphons :-

Syphon No.	Used at Test Section.	Bed Reading. Ft.	Bed Reading Corrected for Syphon Diameter.
1	2	1.243	1.233
2	3	1.326	1.316
3	4	1.300	1.290
4	5	1.267	1.257
5	6	1.066	1.056

Flow Data.

Flow over weir - Free

Gauge reading upstream of weir = 0.794 Feet.

Reading for no flow = 0.587 Feet.

∴ Head over weir = 0.207 Feet.

From flow curve for free flowing weir (Appendix A)

$$Q = 0.0275 \text{ C.F.S.}$$

*This was purchased locally under the trade name of A.S.P. 602.

PROFILE MEASUREMENTS

Test Run 3

Table: 3 - P - 1

Time since test started: 2 Hours

Section.	Bed Reading. Ft.	Density Layer Reading. Ft.	*Top Reading. Ft.	d Col. 3-Col. 2. Ft.	D Col. 4-Col. 2. Ft.	S_o	T ^oF	H Ft.
1	2	3	4	5	6	7	8	9
1	0.072	-	0.631	-	0.559			
2	0.236	0.552	0.776	0.316	0.540	1.0024	74	0.207
3	0.071	0.373	0.624	0.302	0.553			
4	0.104	0.379	0.659	0.275	0.555			
5	0.122	0.357	0.680	0.235	0.558			
6	0.098	-	0.659	-	0.561			

Where d = Thickness of density layer in feet.

D = Total depth of flow in feet.

S_o = Specific gravity of water flowing over weir.

S = Specific gravity of water drawn from any depth at test sections.

T = Temperature of water flowing over weir in ^oF.

H = Head over weir in feet.

*Top readings went on decreasing consistently throughout the test because there was a leakage from the pump at the tail end of the flume.

NOTE: These symbols will have the same interpretation throughout all profile measurements.

Table: 3 - P - 2

Time since test started: 5 Hours

Section.	Bed Reading, Ft.	Density Layer Reading, Ft.	*Top Reading, Ft.	d Col. 3-Col. 2, Ft.	D Col. 4-Col. 2 Ft.	S_o	T °F.	H Ft.
1	2	3	4	5	6	7	8	9
1	0.072	-	0.623	-	0.551			
2	0.236	0.592	0.769	0.356	0.533	1.0028	74.5	0.207
3	0.071	0.419	0.616	0.348	0.545			
4	0.104	0.438	0.651	0.334	0.547			
5	0.122	0.407	0.652	0.285	0.550			
6	0.098	-	0.651	-	0.553			

Table: 3 - P - 3

Time since test started: 7 Hours

1	0.072	-	0.617	-	0.545			
2	0.236	0.610	0.764	0.374	0.528	1.0015	75	0.207
3	0.071	0.439	0.611	0.368	0.540			
4	0.104	0.453	0.646	0.349	0.542			
5	0.122	0.425	0.667	0.303	0.545			
6	0.098	-	0.646	-	0.548			

Table: 3 - P - 4

Time since test started: 17 Hours

1	0.072	-	0.594	-	0.522			
2	0.236	0.608	0.740	0.372	0.504	1.0012	72	0.206
3	0.071	0.433	0.587	0.362	0.516			
4	0.104	0.435	0.622	0.331	0.518			
5	0.122	0.422	0.643	0.300	0.521			
6	0.098	-	0.622	-	0.524			

Table: 3 - P - 5

Time since test started: 27 Hours

Section.	Bed Reading. Ft.	Density Layer Reading. Ft.	*Top Reading. Ft.	d Col. 3- Col. 2 Ft.	D Col. 4- Col. 2 Ft.	S_o	T $^oF.$	H Ft.
1	2	3	4	5	6	7	8	9
1	0.072	-	0.574	-	0.502			
2	0.236	0.600	0.720	0.364	0.484	1.0009	75.5	0.205
3	0.071	0.417	0.567	0.346	0.496			
4	0.104	0.418	0.602	0.314	0.498			
5	0.122	0.400	0.622	0.278	0.500			
6	0.098	-	0.602	-	0.504			

Table: 3 - P - 6

Time since test started: 42 Hours

1	0.072	-	0.556	-	0.484			
2	0.236	0.697	0.710	0.461	0.474	1.0006	73.0	0.205
3	0.071	0.460	0.550	0.389	0.479			
4	0.104	0.443	0.584	0.339	0.480			
5	0.122	0.414	0.605	0.292	0.483			
6	0.098	-	0.584	-	0.486			

Table: 3 - P - 7

Time since test started: 53 Hours

1	0.072	-	0.548	-	0.476			
2	0.236	0.604	0.692	0.368	0.456			
3	0.071	0.425	0.542	0.354	0.471	1.0005	77.0	0.160
4	0.104	0.435	0.577	0.331	0.473			
5	0.122	0.422	0.597	0.300	0.475			
6	0.098	-	0.577	-	0.479			

Table: 3 - P - 8

Time since test started: 67 Hours

Section.	Bed Reading. Ft.	Density Layer Reading. Ft.	*Top Reading. Ft.	d Col. 3- Col. 2 Ft.	D Col. 4- Col. 2 Ft.	S_o	T °F.	H Ft.
1	2	3	4	5	6	7	8	9
1	0.072	-	0.528	-	0.456			
2	0.236	0.582	0.674	0.356	0.438	1.00050	74.0	0.143
3	0.071	0.397	0.522	0.326	0.451			
4	0.104	0.390	0.557	0.286	0.453			
5	0.122	0.377	0.577	0.255	0.455			
6	0.098	-	0.557	-	0.459			

Table: 3 - P - 9

Time since test started: 72 Hours

1	0.072	-	0.522	-	0.450			
2	0.236	0.563	0.667	0.327	0.431			
3	0.071	0.370	0.515	0.299	0.444	1.00050	76.0	0.138
4	0.104	0.375	0.550	0.271	0.446			
5	0.122	0.339	0.571	0.237	0.449			
6	0.098	-	0.550	-	0.452			

Table: 3 - P - 10

Time since test started: 78 Hours

1	0.072	-	0.514	-	0.442			
2	0.236	0.559	0.655	0.323	0.419	1.00045	77.0	0.133
3	0.071	0.364	0.506	0.293	0.435			
4	0.104	0.365	0.540	0.261	0.436			
5	0.122	0.345	0.562	0.223	0.440			
6	0.098	-	0.541	-	0.443			

Table: 3 - P - 11

Time since test started: 90 Hours

Section.	Bed Reading. Ft.	Density Layer Reading. Ft.	*Top Reading. Ft.	d Col. 3- Col. 2 Ft.	D Col. 4- Col. 2 Ft.	S_o	T ^oF.	H Ft.
1	2	3	4	5	6	7	8	9
1	0.072	-	0.496	-	0.422			
2	0.236	0.544	0.641	0.308	0.405	1.00043	74.0	0.116
3	0.071	0.321	0.487	0.250	0.416			
4	0.104	0.344	0.523	0.240	0.419			
5	0.122	Not visible from window	0.543	-	0.421			
6	0.098	-	0.522	-	0.428			

Table: 3 - P - 12

Reading of deposits at bed of flume.

Section	Bed Reading. Ft.	Reading of Deposits at Bed. Ft.	Thickness of Deposits. Ft.	Remarks.
1	0.072	0.088	0.016	These readings were taken 24 hours after the test was stopped and the flume drained out.
2	0.236	0.250	0.014	
3	0.071	0.082	0.011	
4	0.104	0.120	0.016	
5	0.122	0.138	0.016	
6	0.098	0.116	0.018	

CALCULATIONS FOR MAXIMUM VELOCITIES IN THE LOWER LAYER

Test Run 3

Assumption that it occurs at the mid depth of the lower layer.

1. Time since test started: 2 Hours

   Gauge reading upstream of weir: = 0.794 Feet.

   Reading for no flow: = 0.587 Feet.

   ∴ Head over weir = 0.207 Feet.

   From flow curve of weir, running free (Appendix A)

   $$Q = 0.0275 \text{ C.F.S.}$$

   $$\therefore 0.0275 = 1/6 \left[0.300 \times Vm - 0.255 \times 0.125\right]$$

   $$\therefore Vm = 0.657 \text{ inch/sec.}$$

2. Time since test started: 5 Hours

   Gauge reading upstream of weir = 0.794 Feet.

   ∴ As above,

   $$Q = 0.0275 \text{ C.F.S.}$$

   $$\therefore 0.0275 = 1/6 \left[0.350 \times Vm - 0.213 \times 0.185\right]$$

   $$\therefore Vm = 0.583 \text{ inch/sec.}$$

3. Time since test started: 7 Hours

   Gauge reading upstream of weir = 0.794 Feet.

   ∴ As above,

   $$Q = 0.0275 \text{ C.F.S.}$$

   $$\therefore 0.0275 = 3 \left[0.360 \times Vm - 0.182 \times 0.085\right]$$

   $$\therefore Vm = 0.502 \text{ inch/sec.}$$

4. Time since test started: 17 Hours

   Gauge reading upstream of weir = 0.793 Feet.

   Reading for no flow = 0.587 Feet.

   ∴ Head over weir = 0.206 Feet.

From flow curve of weir, running free (Appendix A)

$$Q = 0.0272 \text{ C.F.S.}$$

$$\therefore 0.0272 = 1/6 \left[0.370 \times Vm - 0.148 \times 0.045\right]$$

$$\therefore Vm = 0.458 \text{ inch/sec.}$$

5. Time since test started: 27 Hours

Gauge reading upstream of weir = 0.792 Feet.

Reading for no flow = 0.587 Feet.

$\therefore$ Head over weir = 0.205 Feet.

From flow curve of weir, running free (Appendix A)

$$Q = 0.0270 \text{ C.F.S.}$$

$$\therefore 0.0270 = 1/6 \left[0.330 \times Vm - 0.168 \times 0.088\right]$$

$$\therefore Vm = 0.536 \text{ inch/sec.}$$

6. Time since test started: 42 Hours

Gauge reading upstream of weir = 0.792 Feet.

As in the last case,

$$Q = 0.0270 \text{ C.F.S.}$$

$$\therefore 0.0270 = 1/6 \left[0.380 \times Vm - 0.100 \times 0.06\right]$$

$$\therefore Vm = 0.442 \text{ inch/sec.}$$

7. Time since test started: 53 Hours

Gauge reading upstream of weir = 0.747 Feet.

Reading for no flow = 0.587 Feet.

$\therefore$ Head over weir = 0.160 Feet.

From flow curve of weir, running free (Appendix A)

$$Q = 0.0147 \text{ C.F.S.}$$

$$\therefore 0.0147 = 1/6 \left[0.350 \times Vm - 0.123 \times 0.044\right]$$

$$\therefore Vm = 0.267 \text{ C.F.S.}$$

8. Time since test started: 67 Hours

Gauge reading upstream of weir = 0.730 Feet.

Reading for no flow = 0.587 Feet.

$\therefore$ Head over weir = 0.143 Feet.

From flow curve of weir, running free (Appendix A)

$Q = 0.011$ C.F.S.

$\therefore 0.011 = 1/6 \left[0.315 \times Vm - 0.138 \times 0.056\right]$

$\therefore Vm = 0.234$ inch/sec.

9. Time since test started: 72 Hours

Gauge reading upstream of weir = 0.725 Feet.

Reading for no flow = 0.587 Feet.

$\therefore$ Head over weir = 0.138 Feet.

From flow curve of weir, running free (Appendix A)

$Q = 0.01$ C.F.S.

$\therefore 0.01 = 1/6 \left[0.290 \times Vm - 0.156 \times 0.044\right]$

$\therefore Vm = 0.230$ inch/sec.

10. Time since test started: 78 Hours

Gauge reading upstream of weir = 0.720 Feet.

Reading for no flow = 0.587 Feet.

$\therefore$ Head over weir = 0.133 Feet.

From flow curve of weir, running free (Appendix A)

$Q = 0.0094$ C.F.S.

$\therefore 0.0094 = 1/6 \left[0.270 \times Vm - 0.166 \times 0.045\right]$

$\therefore Vm = 0.237$ inch/sec.

11. Time since test started: 90 Hours

Gauge reading upstream of weir = 0.703 Feet.

Reading for no flow = 0.587 Feet.

∴ Head over weir = 0.116 Feet.

From flow curve of weir, running free (Appendix A)

$$Q = 0.0064 \text{ C.F.S.}$$

$$\therefore 0.0064 = 1/6 \left[0.300 \times Vm - 0.119 \times 0.034\right]$$

$$\therefore Vm = 0.142 \text{ inch/sec.}$$

VELOCITY MEASUREMENTS

Test Run 3

Section of Observation: 4

Distance from upstream sluice gate: 65 Feet.

Table: 3 - V - 1

Time since test started: 2 Hours.

Position From Bed. Ft.	Distance Travelled. Inches.	Time Taken. Secs.	Velocity. Inch/sec.	Remarks.
0.555	-1	34.3	-0.029	Surface, flow downwards.
0.388	-2	16.0	-0.125	
0.358	-2	20.2	-0.099	
0.275	2	24.4	0.082	Interface.
0.150	Refer velocity calculations for lower layer.		0.657	Maximum velocity of lower layer.
0.000	-	-	0.000	Bed.

Table: 3 - V - 2

Time since test started: 5 Hours.

Position From Bed. Ft.	Distance Travelled. Inches.	Time Taken. Secs.	Velocity. Inch/sec.	Remarks.
0.550	-2	36.2	-0.055	Surface.
0.488	-2	18.0	-0.111	
0.446	-3	15.9	-0.189	
0.376	-2	18.2	-0.110	
0.334	1	46.8	0.021	Interface.
0.175	Refer velocity calculations for lower layer		0.583	Maximum velocity of lower layer.
0.000	-	-	0.000	Bed.

Table: 3 - V - 3

Time since test started: 7 Hours.

Position From Bed. Ft.	Distance Travelled. Inches.	Time Taken. Secs.	Velocity. Inch/sec.	Remarks.
0.542	-2	54.4	-0.037	Surface.
0.417	-2	24.4	-0.082	
0.391	-2	26.6	-0.075	
0.349	2	62.0	0.032	Interface.
0.180	Refer velocity calculations for lower layer.		0.502	Maximum velocity of lower layer.
0.000	-	-	0.000	Bed.

Table: 3 - V - 4

Time since test started: 17 Hours.

Position From Bed, Ft.	Distance Travelled. Inches.	Time Taken, Secs.	Velocity. Inch/sec.	Remarks.
0.518	-1	50.0	-0.020	Surface.
0.497	-1	42.8	-0.023	
0.435	-2	50.6	-0.039	
0.352	2	24.6	0.081	
0.331	3	26.8	0.112	Interface.
0.185	Refer velocity calculations for lower layer.		0.458	Maximum velocity of lower layer.
0.000	-	-	0.000	Bed.

Table: 3 - V - 5

Time since test started: 27 Hours

Position From Bed, Ft.	Distance Travelled. Inches.	Time Taken, Secs.	Velocity. Inch/sec.	Remarks.
0.498	-2	40.0	-0.050	Surface.
0.397	-2	23.0	-0.087	
0.335	-2	28.2	-0.071	
0.314	2	23.2	0.086	Interface.
0.165	Refer velocity calculations		0.536	Maximum velocity of lower layer.
0.000	-	-	0.000	Bed.

Table: 3 - V - 6

Time since test started: 42 Hours.

Position From Bed, Ft.	Distance Travelled. Inches.	Time Taken, Secs.	Velocity. Inch/sec.	Remarks.
0.480	-1	27.4	-0.036	Surface.
0.432	-2	44.2	-0.045	
0.422	-2	29.4	-0.068	
0.360	-2	41.0	-0.049	
0.339	2	24.4	0.082	Interface
0.190	Refer velocity calculations for lower layer.		0.442	Maximum velocity of lower layer.
0.000	-	-	0.000	Bed.

Table: 3 - V - 7

Time since test started: 53 Hours.

Position From Bed. Ft.	Distance Travelled. Inches.	Time Taken. Secs.	Velocity. Inch/sec.	Remarks.
0.473	-2	75.6	-0.026	Surface.
0.431	-2	56.8	-0.035	
0.390	-2	45.6	-0.044	
0.373	-2	61.6	-0.032	
0.331	2	46.8	0.043	Interface.
0.175	Refer velocity calculations of lower layer.		0.267	Maximum velocity of lower layer.
0.000	-	-	0.000	Bed.

Table: 3 - V - 8

Time since test started: 67 Hours.

Position From Bed. Ft.	Distance Travelled. Inches.	Time Taken. Secs.	Velocity. Inch/sec.	Remarks.
0.453	-2	45.2	-0.044	Surface.
0.432	-2	47.0	-0.043	
0.370	-2	39.8	-0.050	
0.328	-2	37.4	-0.053	
0.286	2	23.0	0.087	Interface.
0.157	Refer velocity calculations for lower layer.		0.234	Maximum velocity of lower layer.
0.000	-	-	0.000	Bed.

Table: 3 - V - 9

Time since test started: 72 Hours.

Position From Bed. Ft.	Distance Travelled. Inches.	Time Taken. Secs.	Velocity. Inch/sec.	Remarks.
0.446	-	-	0.000	Surface.
0.425	-2	78.0	-0.026	
0.384	-2	54.0	-0.037	
0.363	-2	48.6	-0.041	
0.313	-2	77.6	-0.026	
0.271	2	59.2	0.034	
0.145	Refer velocity calculations for lower layer.		0.230	Maximum velocity of lower layer.
0.000	-	-	0.000	Bed.

Table: 3 - V - 10

Time since test started: 78 Hours

Position From Bed, Ft.	Distance Travelled, Inches,	Time Taken, Secs.	Velocity, Inch/sec.	Remarks.
0.436	-	-	0.000	Surface.
0.316	-2	56.0	-0.036	
0.303	-2	41.2	-0.049	
0.261	2	34.6	0.058	Interface.
0.135	Refer velocity calculations for lower layer.		0.237	Maximum velocity of lower layer.
0.000	-	-	0.000	Bed.

Table: 3 - V - 11

Time since test started: 90 Hours

Position From Bed, Ft.	Distance Travelled, Inches,	Time Taken, Secs.	Velocity, Inch/sec.	Remarks.
0.419	-	-	0.000	Surface.
0.377	-2	62.6	-0.032	
0.336	-2	98.0	-0.020	
0.282	2	30.0	0.067	
0.240	2	27.6	0.072	Interface.
0.150	Refer velocity calculations for lower layer.		0.142	Maximum velocity of lower layer.
0.000	-	-	0.000	Bed.

MEASUREMENTS FOR ALUMINIUM SILICATE CONCENTRATIONS

Test Run 3

Table: 3 - AS - 1

Time since test started: 2 Hours

Section	Bed Reading · Ft.	Depth Reading . Ft.	Depth Ft.	Specific Gravity, S	Remarks
2	1.233	1.343	0.110	1.0024	Near bed.
		1.527	0.294	1.0014	Below interface
		1.596	0.363	1.0004	
		1.743	0.510	0.9998	Near surface .
3	1.316	1.426	0.110	1.0024	Near bed .
		1.598	0.282	1.0014	Below interface
		1.642	0.326	1.0004	
		1.839	0.523	0.9998	Near surface .
4	1.290	1.400	0.110	1.0024	Near bed .
		1.556	0.266	1.0010	
		1.607	0.317	1.0004	
		1.820	0.530	0.9998	Near surface.
5	1.257	1.367	0.110	1.0022	Near bed .
		1.471	0.214	1.0017	
		1.541	0.284	1.0004	
		1.785	0.528	0.9998	Near surface .
6	1.056	1.166	0.110	1.0022	Near bed ,
		1.270	0.214	1.0017	
		1.350	0.294	1.0004	
		1.587	0.531	0.9998	Near surface .

Table: 3 - AS - 2

Time since test started: 5 Hours

Section	Bed Reading . Ft.	Depth Reading . Ft.	Depth Ft.	Specific Gravity . S	Remarks
2	1.233	1.293	0.060	1.0022	Near bed .
		1.343	0.110	1.0022	
		1.565	0.332	1.0020	Below interface
		1.633	0.400	1.0004	Above interface
		1.741	0.508	9.9998	Near surface .
3	1.316	1.376	0.060	1.0022	Near bed .
		1.426	0.110	1.0020	
		1.619	0.303	1.0020	Below interface
		1.700	0.384	1.0004	Above interface
		1.836	0.520	0.9998	Near surface .
4	1.290	1.350	0.060	1.0022	Near bed .
		1.400	0.110	1.0022	
		1.608	0.318	1.0015	Below interface
		1.661	0.371	1.0004	Above interface
		1.812	0.522	0.9998	Near surface .
5	1.257	1.317	0.060	1.0022	Near bed .
		1.367	0.110	1.0019	
		1.553	0.296	1.0012	Below interface
		1.600	0.343	1.0004	Above interface
		1.782	0.525	0.9998	Near surface .
6	1.056	1.116	0.060	1.0022	Near bed .
		1.166	0.110	1.0020	
		1.350	0.294	1.0012	Below interface
		1.400	0.344	1.0004	Above interface
		1.584	0.528	0.9998	Near surface .

Table: 3 - AS - 3

Time since test started: 7 Hours

Section	Bed Reading, Ft.	Depth Reading, Ft.	Depth Ft.	Specific Gravity, S	Remarks
2	1.233	1.293	0.060	1.0020	Near bed.
		1.575	0.342	1.0017	Below interface
		1.644	0.411	1.0004	Above interface
		1.736	0.503	0.9998	Near surface.
3	1.316	1.376	0.060	1.0019	Near bed,
		1.647	0.331	1.0016	Below interface
		1.717	0.401	1.0004	Above interface
		1.831	0.515	0.9998	Near surface,
4	1.290	1.350	0.060	1.0019	Near bed.
		1.619	0.329	1.0017	Below interface
		1.677	0.387	1.0004	Above interface
		1.807	0.517	0.9998	Near surface.
5	1.257	1.317	0.060	1.0018	Near bed.
		1.550	0.293	1.0016	Below interface
		1.600	0.343	1.0004	Above interface
		1.777	0.520	0.9998	Near surface.
6	1.056	1.116	0.060	1.0019	Near bed.
		1.350	0.294	1.0012	
		1.400	0.344	1.0004	Above interface
		1.579	0.523	0.9998	Near surface.

Table: 3 - AS - 4

Time since test started: 17 Hours

Section	Bed Reading, Ft.	Depth Reading, Ft.	Depth Ft.	Specific Gravity, S	Remarks
2	1.233	1.293	0.060	1.0015	Near bed.
		1.595	0.362	1.0015	Below interface
		1.647	0.414	1.0004	Above interface
		1.713	0.480	1.0000	Near surface.
3	1.316	1.376	0.060	1.0014	Near bed,
		1.639	0.323	1.0014	Below interface
		1.710	0.394	1.0004	Above interface
		1.806	0.490	1.0000	Near surface,
4	1.290	1.350	0.060	1.0015	Near bed,
		1.610	0.320	1.0009	Below interface
		1.642	0.352	1.0004	Above interface
		1.780	0.490	1.0000	Near surface.
5	1.257	1.317	0.060	1.0015	Near bed,
		1.546	0.289	1.0014	Below interface
		1.630	0.373	1.0004	Above interface
		1.748	0.491	1.0000	Near surface,
6	1.056	1.116	0.060	1.0015	Near bed,
		1.350	0.294	1.0006	
		1.400	0.344	1.0004	
		1.544	0.488	1.0000	Near surface,

Table: 3 - AS - 5

Time since test started: 27 Hours

Section	Bed Reading, Ft.	Depth Reading. Ft.	Depth Ft.	Specific Gravity, S	Remarks
2	1.233	1.293	0.060	1.0012	Near bed.
		1.557	0.324	1.0010	Below interface
		1.631	0.398	1.0004	Above interface
		1.690	0.457	1.0000	Near surface.
3	1.316	1.376	0.060	1.0012	Near bed,
		1.595	0.279	1.0012	Below interface
		1.687	0.371	1.0004	Above interface
		1.784	0.468	1.0000	Near surface.
4	1.290	1.350	0.060	1.0010	Near bed.
		1.569	0.279	1.0010	Below interface
		1.631	0.341	1.0004	Above interface
		1.760	0.470	1.0000	Near surface.
5	1.257	1.317	0.060	1.0012	Near bed,
		1.495	0.238	1.0011	Below interface
		1.607	0.350	1.0004	Above interface
		1.727	0.470	1.0000	Near surface.
6	1.056	1.116	0.060	1.0014	Near bed,
		1.311	0.255	1.0006	
		1.400	0.344	1.0004	
		1.530	0.474	1.0000	Near surface,

Table: 3 - AS - 6

Time since test started: 42 Hours

Section	Bed Reading, Ft.	Depth Reading, Ft.	Depth Ft.	Specific Gravity. S	Remarks
2	1.233	1.293 1.483 1.682	0.060 0.250 0.449	1.0006 1.0006 1.0001	Near bed, Below interface Near surface.
3	1.316	1.376 1.667 1.722 1.770	0.060 0.351 0.406 0.454	1.0006 1.0006 1.0004 1.0001	Near bed. Below interface Above interface Near surface.
4	1.290	1.350 1.639 1.680 1.745	0.060 0.349 0.390 0.455	1.0006 1.0005 1.0004 1.0001	Near bed. Near surface.
5	1.257	1.317 1.493 1.625 1.715	0.060 0.236 0.368 0.458	1.0006 1.0006 1.0004 1.0001	Near bed. Near surface.
6	1.056	1.116 1.310 1.400 1.517	0.060 0.254 0.344 0.461	1.0009 1.0005 1.0004 1.0001	Near bed. Near surface.

Table: 3 - AS - 7

Time since test started: 53 Hours

Section	Bed Reading, Ft.	Depth Reading, Ft.	Depth Ft.	Specific Gravity, S	Remarks
2	1.233	1.293	0.060	1.0006	Near bed.
		1.558	0.325	1.0005	Below interface
		1.643	0.410	1.0001	Above interface
		1.664	0.431	1.0001	Near surface.
3	1.316	1.376	0.060	1.0006	Near bed.
		1.608	0.292	1.0006	Below interface
		1.670	0.354	1.0002	Above interface
		1.762	0.446	1.0001	Near surface.
4	1.290	1.350	0.060	1.0006	Near bed.
		1.574	0.284	1.0006	Below interface
		1.700	0.410	1.0002	Above interface
		1.738	0.448	1.0001	Near surface.
5	1.257	1.317	0.060	1.0006	Near bed.
		1.538	0.281	1.0005	Below interface
		1.588	0.331	1.0001	Above interface
		1.707	0.450	1.0001	Near surface.
6	1.056	1.116	0.060	1.0007	Near bed.
		1.336	0.280	1.0005	
		1.393	0.337	1.0002	
		1.510	0.454	1.0001	Near surface.

*Table: 3 - AS - 8

Time since test started: 67 Hours

Section	Bed Reading, Ft.	Depth Reading, Ft.	Depth Ft.	Specific Gravity, S	Remarks
2	1.233	1.293 1.584 1.646	0.060 0.351 0.413	1.00060 1.00050 1.00015	Near bed. Near surface.
3	1.316	1.376 1.617 1.741	0.060 0.301 0.425	1.00060 1.00050 1.00015	Near bed. Near surface.
4	1.290	1.350 1.605 1.717	0.060 0.315 0.427	1.00060 1.00050 1.00015	Near bed. Near surface.
5	1.257	1.317 1.566 1.686	0.060 0.309 0.429	1.00060 1.00040 1.00015	Near bed. Near surface.
6	1.056	1.116 1.367 1.489	0.060 0.311 0.433	1.00060 1.00040 1.00015	Near bed. Near surface.

*At this time a uniform gradient had developed in the layer above the density layer. Therefore interface was no longer clearly visible through the windows at test sections 2 to 5.

Table: 3 - AS - 9

Time since test started: 72 Hours

Section	Bed Reading, Ft.	Depth Reading, Ft.	Depth Ft.	Specific Gravity, S	Remarks
2	1.233	1.293 1.593 1.639	0.060 0.360 0.406	1.00060 1.00040 1.00015	Near bed. Near surface.
3	1.316	1.376 1.613 1.635	0.060 0.297 0.319	1.00060 1.00050 1.00015	Near bed. Near surface.
4	1.290	1.350 1.578 1.611	0.060 0.288 0.321	1.00060 1.00050 1.00015	Near bed. Near surface.
5	1.257	1.317 1.483 1.581	0.060 0.226 0.324	1.00060 1.00060 1.00015	Near bed. Near surface.
6	1.056	1.116 1.296 1.383	0.060 0.240 0.327	1.00060 1.00050 1.00015	Near bed. Near surface.

Table: 3 - AS - 10

Time since test started: 78 Hours

Section	Bed Reading, Ft.	Depth Reading, Ft.	Depth Ft.	Specific Gravity, S	Remarks
2	1.233	1.293 1.448 1.627	0.060 0.215 0.394	1.00060 1.00050 1.00015	Near bed. Near surface.
3	1.316	1.376 1.520 1.726	0.060 0.204 0.410	1.00060 1.00050 1.00015	Near bed. Near surface.
4	1.290	1.350 1.560 1.701	0.060 0.270 0.411	1.00060 1.00050 1.00015	Near bed. Near surface.
5	1.257	1.317 1.540 1.675	0.060 0.283 0.418	1.00060 1.00015 1.00015	Near bed. Near surface.
6	1.056	1.116 1.300 1.477	0.060 0.244 0.421	1.00060 1.00015 1.00015	Near bed. Near surface.

Table: 3 - AS - 11

Time since test started: 90 Hours

Section	Bed Reading, Ft.	Depth Reading, Ft.	Depth Ft.	Specific Gravity, S	Remarks
2	1.233	1.293 1.530 1.608	0.060 0.297 0.375	1.00060 1.00060 1.00015	Near bed. Near surface.
3	1.316	1.376 1.540 1.690	0.060 0.224 0.380	1.00060 1.00050 1.00015	Near bed, Near surface.
4	1.290	1.350 1.510 1.672	0.060 0.220 0.382	1.00060 1.00050 1.00015	Near bed. Near surface.
5	1.257	1.317 1.390 1.642	0.060 0.133 0.385	1.00060 1.00060 1.00015	Near bed. Near surface.
6	1.056	1.116 1.166 1.459	0.060 0.110 0.403	1.00060 1.00060 1.00015	Near bed. Near surface.

Test Run 4

General Data.

Material Used: Aluminium silicate.

Flume: Level

Sluice Gate Opening: 4"

Test Started: 12:40 on 20.8.64

Duration of Test: 72 Hours

Observation Time: 2, 4, 8, 20, 24, 30, 34, 46, 48, 52, 58, and 70 hours after the start of the test.

Data of Syphons.

Syphon No.	Used at Test Section.	Bed Reading. Ft.	Bed Reading Corrected for Syphon Diameter.
1	2	1.243	1.233
2	3	1.301	1.291
3	4	1.300	1.290
4	5	1.266	1.256
5	6	1.065	1.055

Flow Data.

Flow over weir - Free.

Gauge reading upstream of weir = 0.872 Feet.

Reading for no flow = 0.587 Feet.

∴ Head over weir = 0.285 Feet.

From flow curve for free flowing weir (Appendix A)

Q = 0.061 C.F.S.

PROFILE MEASUREMENTS

Test Run: 4

Table: 4 - P - 1

Time since test started: 2 Hours

Section.	Bed Reading. Ft.	Density Layer Reading. Ft.	*Top Reading. Ft.	d Col. 3-Col. 2. Ft.	D Col. 4-Col. 2 Ft.	S_o	T °F.	H Ft.
1	2	3	4	5	6	7	8	9
1	0.072	-	0.637	-	0.565			
2	0.236	0.543	0.782	0.307	0.546	1.0068	76.0	0.285
3	0.071	0.382	0.630	0.311	0.559			
4	0.104	0.405	0.664	0.301	0.560			
5	0.122	0.412	0.685	0.290	0.563			
6	0.098	-	0.664	-	0.566			

Where d = Thickness of density layer in feet.

D = Total depth of flow in feet.

S_o = Specific gravity of water flowing over weir.

S = Specific gravity of water drawn from any depth at test sections.

T = Temperature of water flowing over weir in °F.

H = Head over weir in feet.

*Top readings went on decreasing consistently throughout the test, because there was a leakage from the pump at the tail end of the flume.

NOTE: These symbols will have the same interpretation throughout all profile measurements.

Table: 4 - P - 2

Time since test started: 4 Hours

Section.	Bed Reading. Ft.	Density Layer Reading. Ft.	*Top Reading. Ft.	d Col. 3- Col. 2 Ft.	D Col. 4- Col. 2 Ft.	S_o	T ^oF.	H Ft.
1	2	3	4	5	6	7	8	9
1	0.072	-	0.636	-	0.564			
2	0.236	0.565	0.781	0.329	0.545	1.0058	78.5	0.285
3	0.071	0.405	0.629	0.334	0.558			
4	0.104	0.430	0.663	0.326	0.559			
5	0.122	0.422	0.684	0.300	0.562			
6	0.098	-	0.663	-	0.565			

Table: 4 - P - 3

Time since test started: 8 Hours

1	0.072	-	0.633	-	0.561			
2	0.236	0.571	0.779	0.335	0.543	1.0053	78.5	0.286
3	0.071	0.409	0.627	0.338	0.556			
4	0.104	0.438	0.661	0.334	0.557			
5	o.122	0.432	0.682	0.310	0.560			
6	0.098	-	0.662	-	0.564			

Table: 4 - P - 4

Time since test started: 20 Hours

1	0.072	-	0.627	-	0.555			
2	0.236	0.592	0.770	0.356	0.534	1.0048	77.5	0.286
3	0.071	0.423	0.620	0.352	0.549			
4	0.104	0.428	0.653	0.324	0.549			
5	0.122	0.416	0.674	0.294	0.552			
6	0.098	-	0.653	-	0.555			

Table: 4 - P - 5

Time since test started: 24 Hours

Section.	Bed Read-ing. Ft.	Density Layer Reading. Ft.	*Top Reading. Ft.	d Col. 3- Col. 2 Ft.	D Col. 4- Col. 2 Ft.	S_o	T °F.	H Ft.
1	2	3	4	5	6	7	8	9
1	0.072	-	0.624	-	0.554			
2	0.236	0.588	0.767	0.352	0.531	1.0042	77.0	0.286
3	0.071	0.420	0.618	0.349	0.547			
4	0.104	0.425	0.650	0.321	0.546			
5	0.122	0.412	0.672	0.290	0.550			
6	0.098	-	0.650	-	0.552			

Table: 4 - P - 6

Time since test started: 30 Hours

Section.	Bed Read-ing. Ft.	Density Layer Reading. Ft.	*Top Reading. Ft.	d Col. 3- Col. 2 Ft.	D Col. 4- Col. 2 Ft.	S_o	T °F.	H Ft.
1	0.072	-	0.617	-	0.545			
2	0.236	0.594	0.765	0.358	0.529	1.0040	77.0	0.286
3	0.071	0.431	0.614	0.360	0.543			
4	0.104	0.437	0.647	0.333	0.543			
5	0.122	0.421	0.667	0.299	0.545			
6	0.098	-	0.647	-	0.549			

Table: 4 - P - 7

Time since test started: 34 Hours

Section.	Bed Read-ing. Ft.	Density Layer Reading. Ft.	*Top Reading. Ft.	d Col. 3- Col. 2 Ft.	D Col. 4- Col. 2 Ft.	S_o	T °F.	H Ft.
1	0.072	-	0.617	-	0.545			
2	0.236	0.613	0.763	0.377	0.527	1.0038	78.0	0.286
3	0.071	0.434	0.609	0.363	0.538			
4	0.104	0.439	0.643	0.335	0.539			
5	0.122	0.424	0.664	0.302	0.542			
6	0.098	-	0.645	-	0.547			

Table: 4 - P - 8

Time since test started: 46 Hours

Section	Bed Reading Ft.	Density Layer Reading Ft.	*Top Reading Ft.	d Col. 3-Col. 2 Ft.	D Col. 4-Col. 2 Ft.	S_o	T °F.	H Ft.
1	2	3	4	5	6	7	8	9
1	0.072	-	0.605	-	0.533	1.0036	76.0	0.286
2	0.236	0.664	0.752	0.428	0.516			
3	0.071	0.467	0.600	0.396	0.529			
4	0.104	0.468	0.634	0.364	0.530			
5	0.122	0.440	0.653	0.318	0.531			
6	0.098	-	0.635	-	0.537			

Table: 4 - P - 9

Time since test started: 48 Hours

Section	Bed Reading Ft.	Density Layer Reading Ft.	*Top Reading Ft.	d Col. 3-Col. 2 Ft.	D Col. 4-Col. 2 Ft.	S_o	T °F.	H Ft.
1	0.072	-	0.605	-	0.533	1.0034	75.5	0.286
2	0.236	0.674	0.751	0.438	0.515			
3	0.071	0.472	0.599	0.401	0.528			
4	0.104	0.463	0.634	0.359	0.530			
5	0.122	0.448	0.653	0.326	0.531			
6	0.098	-	0.632	-	0.534			

Table: 4 - P - 10

Time since test started: 52 Hours

Section	Bed Reading Ft.	Density Layer Reading Ft.	*Top Reading Ft.	d Col. 3-Col. 2 Ft.	D Col. 4-Col. 2 Ft.	S_o	T °F.	H Ft.
1	0.072	-	0.600	-	0.528	1.0033	75.0	0.285
2	0.236	0.690	0.747	0.454	0.511			
3	0.071	0.486	0.597	0.413	0.526			
4	0.104	0.479	0.629	0.375	0.525			
5	0.122	0.460	0.652	0.338	0.530			
6	0.098	-	0.632	-	0.534			

Table: 4 - P - 11

Time since test started: 58 Hours

Section	Bed Reading Ft.	Density Layer Reading Ft.	*Top Reading Ft.	d Col. 3- Col. 2 Ft.	D Col. 4- Col. 2 Ft.	S_o	T °F.	H Ft.
1	2	3	4	5	6	7	8	9
1	0.072	-	0.600	-	0.528			
2	0.236	0.712	0.745	0.476	0.509	1.0030	77.00	0.285
3	0.071	0.495	0.592	0.424	0.521			
4	0.104	0.485	0.627	0.381	0.523			
5	0.122	0.465	0.647	0.343	0.525			
6	0.098	-	0.626	-	0.528			

Table: 4 - P - 12

Time since test started: 70 Hours

Section	Bed Reading Ft.	Density Layer Reading Ft.	*Top Reading Ft.	d Col. 3- Col. 2 Ft.	D Col. 4- Col. 2 Ft.	S_o	T °F.	H Ft.
1	0.072	-	0.590	-	0.518			
2	0.236	0.734	0.734	0.498	0.498	1.0028	76.25	0.285
3	0.071	0.576	0.584	0.505	0.513			
4	0.104	0.519	0.617	0.415	0.513			
5	0.122	0.483	0.637	0.361	0.515			
6	0.098	-	0.618	-	0.520			

Table: 4 - P - 13

Reading of deposits at bed of flume.

Section	Bed Reading Ft.	Reading of Deposits at Bed Ft.	Thickness of Deposits. Ft.	Remarks
1	0.072	0.079	0.007	These readings were taken 24 hours after the test was stopped and the flume drained out.
2	0.236	0.241	0.005	
3	0.071	0.078	0.007	
4	0.104	0.109	0.005	
5	0.122	0.129	0.007	
6	0.098	0.105	0.007	

OBSERVATIONS FOR TEMPERATURE GRADIENT

Test Run 4

Section of Observation: 4

Distance From Upstream Gate: 65 Feet.

*Table: 4 - T - 10

Time since test started: 52 Hours

Section.	Bed Reading. Ft.	Depth Reading. Ft.	Depth. Ft.	T °F.	Remarks.
4	1.256	1.316	0.060	74.00	Near bed.
		1.606	0.350	74.00	
		1.686	0.430	74.70	
		1.781	0.525	75.00	Surface.

/Table: 4 - T - 11

Time since test started: 58 Hours

Section.	Bed Reading. Ft.	Depth Reading. Ft.	Depth. Ft.	T °F.	Remarks.
4	1.256	1.316	0.060	76.00	Near bed.
		1.616	0.360	76.00	
		1.686	0.430	76.75	
		1.781	0.525	77.00	Surface.

*This table corresponds to 4 - P - 10 and 4 - AS - 10.

/This table corresponds to 4 - P - 11 and 4 - AS - 11.

VELOCITY MEASUREMENTS

Test Run 4

Section of Observation: 4

Distance From Upstream Sluice Gate: 65 Feet.

Table: 4 - V - 1

Time Since Test Started: 2 Hours

Position From Bed Ft.	Distance Travelled Inches	Time Taken Secs.	Velocity Inch/sec.	Remarks
0.560	-1	41.6	-0.024	Surface.
0.518	-4	24.2	-0.165	
0.426	-3	15.6	-0.192	
0.405	-4	21.4	-0.187	
0.332	-2	19.0	-0.105	
0.301	3	24.9	0.121	Interface.
0.160	By similar calculations as made in Test Run 3.		1.290	Maximum velocity of lower layer.
0.000	-	-	0.000	Bed.

Table: 4 - V - 2

Time since test started: 4 Hours.

Position From Bed Ft.	Distance Travelled Inches	Time Taken Secs.	Velocity Inch/sec.	Remarks
0.559	-2	38.2	-0.052	Surface.
0.497	-2	28.6	-0.070	
0.451	-2	26.8	-0.075	
0.368	-3	13.5	-0.222	
0.326	4	12.2	0.328	Interface.
0.170	By similar calculations as made in Test Run 3.		1.220	Maximum velocity of lower layer.
0.000	-	-	0.000	Bed.

Table: 4 - V - 3

Time since test started: 8 Hours.

Position From Bed Ft.	Distance Travelled Inches	Time Taken Secs.	Velocity Inch/sec.	Remarks
0.557	-2	23.0	-0.087	Surface.
0.495	-2	20.4	-0.098	
0.453	-2	12.6	-0.159	
0.334	4	12.4	0.323	Interface.
0.190	By similar calculations as made in Test Run 3.		1.053	
0.000	-	-	0.000	Bed.

Table: 4 - V - 4

Time since test started: 20 Hours.

Position From Bed Ft.	Distance Travelled Inches	Time Taken Secs.	Velocity Inch/sec.	Remarks
0.549	-3	25.9	-0.116	Surface.
0.508	-4	24.4	-0.164	
0.407	-4	38.8	-0.103	
0.324	4	18.4	0.217	Interface.
0.200	By similar calculations as made in Test Run 3.		0.990	
0.000	-	-	0.000	Bed.

Table: 4 - V - 5

Time since test started: 24 Hours.

Position From Bed Ft.	Distance Travelled Inches	Time Taken Secs.	Velocity Inch/sec.	Remarks
0.546	-2	63.2	-0.032	Surface.
0.404	-2	26.9	-0.074	
0.363	-3	39.3	-0.076	
0.321	4	12.6	0.317	Interface.
0.175	By similar calculations as made in Test Run 3.		1.110	Maximum velocity of lower layer.
0.000	-	-	0.000	Bed.

Table: 4 - V - 6

Time since test started: 30 Hours.

Position From Bed Ft.	Distance Travelled Inches	Time Taken Secs.	Velocity Inch/sec.	Remarks
0.543	-3	33.6	-0.089	Surface.
0.460	-3	19.5	-0.154	
0.395	-3	21.9	-0.137	
0.333	4	14.0	0.286	Interface.
0.180	By similar calculations as made in Test Run 3.		1.113	Maximum velocity of lower layer.
0.000	-	-	0.000	Bed.

Table: 4 - V - 7

Time since test started: 34 Hours.

Position From Bed Ft.	Distance Travelled Inches	Time Taken Secs.	Velocity Inch/sec.	Remarks
0.539	-2	25.0	-0.080	Surface.
0.497	-2	16.4	-0.122	
0.456	-2	15.4	-0.130	
0.418	-3	17.7	-0.169	
0.335	3	14.4	0.208	Interface.
0.180	By similar calculations as made in Test Run 3.		1.120	Maximum velocity of lower layer.
0.000	-	-	0.000	Bed.

Table: 4 - V - 8

Time since test started: 46 Hours

Position From Bed Ft.	Distance Travelled Inches	Time Taken Secs.	Velocity Inch/sec.	Remarks
0.530	-3	37.2	-0.081	Surface.
0.447	-2	34.2	-0.058	
0.426	-2	28.8	-0.069	
0.364	2	11.0	0.182	Interface.
0.200	By similar calculations as made in Test Run 3.		0.953	Maximum velocity of lower layer.
0.000	-	-	0.000	Bed.

Table: 4 - V - 9

Time since test started: 48 Hours.

Position From Bed Ft.	Distance Travelled Inches	Time Taken Secs.	Velocity Inch/sec.	Remarks
0.530	-3	29.7	-0.101	Surface.
0.447	-4	21.2	-0.189	
0.380	-2	17.2	-0.116	
0.359	4	12.4	0.323	Interface.
0.190	By similar calculations as made in Test Run 3.		1.054	Maximum velocity of lower layer.
0.000	-	-	0.000	Bed.

Table: 4 - V - 10

Time since test started: 52 Hours.

Position From Bed Ft.	Distance Travelled Inches	Time Taken Secs.	Velocity Inch/sec.	Remarks
0.525	-4	42.8	-0.093	Surface.
0.504	-4	32.0	-0.125	
0.437	-3	21.9	-0.137	
0.375	4	20.0	0.200	Interface.
0.195	By similar calculations as shown in Test Run 3.		0.988	Maximum velocity of lower layer.
0.000	-	-	0.000	Bed.

Table: 4 - V - 11

Time since test started: 58 Hours.

Position From Bed Ft.	Distance Travelled Inches	Time Taken Secs.	Velocity Inch/sec.	Remarks
0.523	-	-	0.000	Surface.
0.464	-2	17.0	-0.118	
0.423	-2	18.6	-0.107	
0.381	2	10.0	0.200	Interface.
0.195	By similar calculations as made in Test Run 3.		0.979	Maximum velocity of lower layer.
0.000	-	-	0.000	Bed.

Table: 4 - V - 12

Time since test started: 70 Hours.

Position From Bed Ft.	Distance Travelled Inches	Time Taken Secs.	Velocity Inch/sec.	Remarks
0.513	-	-	0.000	Surface.
0.492	-2	47.0	-0.043	
0.457	-2	30.6	-0.065	
0.415	2	10.2	0.196	Interface.
0.210	By similar calculations as made in Test Run 3.		0.755	Maximum velocity of lower layer.
0.000	-	-	0.000	Bed.

MEASUREMENTS FOR ALUMINIUM SILICATE CONCENTRATION

Test Run 4

Table: 4 - AS - 1

Time since test started: 2 Hours

Section	Bed Reading. Ft.	Depth Reading. Ft.	Depth Ft.	Specific Gravity. S	Remarks
2	1.233		0.060	1.0068	Near bed.
		1.533	0.300	1.0058	Below interface
		1.585	0.352	0.9998	Above interface
		1.759	0.526	0.9998	Near surface.
3	1.291	1.351	0.060	1.0068	Near bed.
		1.570	0.279	1.0058	Below interface
		1.657	0.366	0.9998	Above interface
		1.830	0.539	0.9998	Near surface.
4	1.290		0.060	1.0068	Near bed.
		1.560	0.270	1.0057	Below interface
		1.644	0.354	0.9999	Above interface
		1.830	0.540	0.9998	Near surface.
5	1.256		0.060	1.0068	Near bed,
		1.539	0.283	1.0028	Below interface
		1.650	0.394	0.9995	Above interface
		1.799	0.543	0.9998	Near surface
6	1.055	1.115	0.060	1.0068	Near bed,
		1.325	0.270	1.0051	
		1.521	0.466	0.9998	Above interface
		1.598	0.543	0.9998	Near surface.

Table: 4 - AS - 2

Time since test started: 4 Hours

Section	Bed Reading, Ft.	Depth Reading. Ft.	Depth Ft.	Specific Gravity. S	Remarks
2	1.233	1.293 1.537 1.600 1.758	0.060 0.304 0.367 0.525	1.0059 1.0058 1.0000 0.9998	Near bed, Below interface Above interface Near surface.
3	1.291	1.351 1.587 1.679 1.829	0.060 0.296 0.388 0.538	1.0058 1.0055 0.9998 0.9998	Near bed. Below interface Above interface Near surface.
4	1.290	1.350 1.577 1.663 1.829	0.060 0.287 0.373 0.539	1.0060 1.0056 0.9999 0.9998	Near bed, Below interface Above interface Near surface .
5	1.256	1.316 1.520 1.640 1.798	0.060 0.264 0.384 0.542	1.0059 1.0052 0.9998 0.9998	Near bed . Below interface Above interface Near surface.
6	1.055	1.115 1.325 1.450 1.600	0.060 0.270 0.395 0.545	1.0059 1.0047 0.9998 0.9998	Near bed , Below interface Above interface Near surface .

Table: 4 - AS - 3

Time since test started: 8 Hours

Section	Bed Reading, Ft.	Depth Reading. Ft.	Depth Ft.	Specific Gravity, S	Remarks
2	1.233	1.293	0.060	1.0055	Near bed.
		1.545	0.312	1.0053	Below interface.
		1.611	0.378	1.0000	Above interface.
		1.756	0.523	0.9999	Near surface,
3	1.291	1.351	0.060	1.0053	Near bed.
		1.588	0.297	1.0053	Below interface
		1.674	0.383	0.9999	Above interface.
		1.827	0.536	0.9999	Near surface,
4	1.290	1.350	0.060	1.0053	Near bed.
		1.576	0.286	1.0052	Below interface
		1.670	0.380	0.9999	Above interface.
		1.827	0.537	0.9999	Near surface.
5	1.256	1.316	0.060	1.0055	Near bed,
		1.550	0.294	1.0026	Below interface.
		1.660	0.404	0.9999	Above interface.
		1.796	0.540	0.9999	Near surface,
6	1.055	1.115	0.060	1.0055	Near bed,
		1.350	0.295	1.0021	Below interface
		1.490	0.435	0.9999	Above interface
		1.599	0.544	0.9999	Near surface.

Table: 4 - AS - 4

Time since test started: 20 Hours

Section	Bed Reading, Ft.	Depth Reading, Ft.	Depth Ft.	Specific Gravity, S	Remarks
2	1.233	1.293	0.060	1.0047	Near bed,
		1.562	0.329	1.0047	Below interface.
		1.644	0.411	1.0000	Above interface.
		1.747	0.514	1.0000	Near surface,
3	1.291	1.351	0.060	1.0048	Near bed,
		1.609	0.318	1.0046	Below interface,
		1.678	0.387	1.0000	Above interface
		1.820	0.529	1.0000	Near surface.
4	1.290	1.350	0.060	1.0048	Near bed.
		1.620	0.330	1.0008	Above interface.
		1.698	0.408	1.0000	
		1.819	0.529	1.0000	Near surface.
5	1.256	1.316	0.060	1.0043	Near bed,
		1.550	0.294	1.0014	Above interface
		1.660	0.404	1.0000	
		1.788	0.532	1.0000	Near surface.
6	1.055	1.115	0.060	1.0046	Near bed,
		1.320	0.265	1.0042	Below interface
		1.490	0.435	1.0000	Above interface
		1.590	0.535	1.0000	Near surface .

Table: 4 - AS - 5

Time since test started: 24 Hours

Section	Bed Reading, Ft.	Depth Reading, Ft.	Depth Ft.	Specific Gravity, S	Remarks
2	1.233	1.293	0.060	1.0046	Near bed.
		1.560	0.327	1.0045	Below interface
		1.630	0.397	1.0001	Above interface
		1.744	0.511	1.0001	Near surface.
3	1.291	1.351	0.060	1.0046	Near bed.
		1.620	0.329	1.0046	Below interface
		1.680	0.389	1.0000	Above interface.
		1.818	0.527	1.0000	Near surface.
4	1.290	1.350	0.060	1.0046	Near bed,
		1.600	0.310	1.0028	Below interface.
		1.660	0.370	1.0000	Above interface
		1.816	0.526	1.0000	Near surface.
5	1.256	1.316	0.060	1.0043	Near bed.
		1.530	0.274	1.0036	Below interface
		1.600	0.344	1.0001	Above interface
		1.786	0.530	1.0000	Near surface,
6	1.055	1.115	0.060	1.0043	Near bed.
		1.325	0.270	1.0038	Below interface
		1.400	0.345	1.0001	Above interface
		1.587	0.532	1.0001	Near surface.

Table: 4 - AS 6

Time since test started: 30 Hours

Section	Bed Reading, Ft.	Depth Reading, Ft.	Depth Ft.	Specific Gravity, S	Remarks
2	1.233	1.293	0.060	1.0043	Near bed.
		1.570	0.337	1.0043	Below interface
		1.643	0.410	1.0001	Above interface
		1.742	0.509	1.0001	Near surface.
3	1.291	1.351	0.060	1.0041	Near bed.
		1.630	0.339	1.0038	Below interface
		1.680	0.389	1.0001	Above interface
		1.814	0.523	1.0001	Near surface.
4	1.290	1.350	0.060	1.0043	Near bed.
		1.590	0.300	1.0043	Below interface
		1.660	0.370	1.0001	Above interface
		1.813	0.523	1.0001	Near surface.
5	1.256	1.316	0.060	1.0042	Near bed.
		1.520	0.264	1.0042	Below interface
		1.620	0.364	1.0001	Above interface
		1.781	0.525	1.0001	Near surface.
6	1.055	1.115	0.060	1.0042	Near bed.
		1.325	0.270	1.0042	Below interface
		1.415	0.360	1.0001	Above interface
		1.584	0.529	1.0001	Near surface.

Table: 4 - AS - 7

Time since test started: 34 Hours

Section	Bed Reading. Ft.	Depth Reading. Ft.	Depth Ft.	Specific Gravity. S	Remarks
2	1.233	1.293 1.580 1.660 1.740	0.060 0.347 0.427 0.507	1.0039 1.0039 1.0002 1.0001	Near bed, Below interface. Above interface. Near surface.
3	1.291	1.351 1.630 1.700 1.809	0.060 0.339 0.409 0.518	1.0039 1.0039 1.0001 1.0001	Near bed. Below interface. Above interface. Near surface.
4	1.290	1.350 1.600 1.680 1.809	0.060 0.310 0.390 0.519	1.0039 1.0039 1.0001 1.0001	Near bed. Below interface Above interface Near surface.
5	1.256	1.316 1.530 1.620 1.778	0.060 0.274 0.364 0.522	1.0039 1.0039 1.0001 1.0001	Near bed, Below interface. Above interface Near surface,
6	1.055	1.115 1.335 1.415 1.582	0.060 0.280 0.360 0.527	1.0039 1.0034 1.0001 1.0001	Near bed. Below interface Above interface. Near surface,

Table: 4 - AS - 8

Time since test started: 46 Hours

Section	Bed Reading, Ft.	Depth Reading, Ft.	Depth . Ft.	Specific Gravity, S	Remarks
2	1.233	1.293	0.060	1.0035	Near bed,
		1.623	0.390	1.0035	Below interface
		1.700	0.467	1.0002	Above interface
		1.729	0.496	1.0001	Near surface,
3	1.291	1.351	0.060	1.0035	Near bed,
		1.650	0.359	1.0035	Below interface
		1.731	0.440	1.0001	Above interface
		1.800	0.509	1.0001	Near surface,
4	1.290	1.350	0.060	1.0035	Near bed,
		1.620	0.330	1.0035	Below interface
		1.700	0.410	1.0002	Above interface
		1.800	0.510	1.0001	Near surface,
5	1.256	1.316	0.060	1.0036	Near bed,
		1.530	0.274	1.0036	Below interface
		1.620	0.364	1.0002	Above interface
		1.767	0.511	1.0001	Near surface.
6	1.055	1.115	0.060	1.0036	Near bed.
		1.325	0.270	1.0036	Below interface
		1.425	0.370	1.0001	Above interface
		1.572	0.517	1.0001	Near surface,

Table: 4 - AS - 9

Time since test started: 48 Hours

Section	Bed Reading . Ft.	Depth Reading . Ft.	Depth Ft.	Specific Gravity. S	Remarks
2	1.233	1.293	0.060	1.0035	Near bed ,
		1.643	0.410	1.0035	Below interface.
		1.713	0.480	1.0003	Above interface .
		1.728	0.495	1.0002	Near surface ,
3	1.291	1.351	0.060	1.0035	Near bed ,
		1.661	0.370	1.0035	Below interface
		1.730	0.439	1.0002	Above interface
		1.799	0.508	1.0002	Near surface ,
4	1.290	1.350	0.060	1.0035	Near bed ,
		1.620	0.330	1.0030	Below interface
		1.690	0.400	1.0002	Above interface
		1.800	0.510	1.0002	Near surface ,
5	1.256	1.316	0.060	1.0035	Near bed ,
		1.556	0.300	1.0032	Below interface
		1.620	0.364	1.0002	Above interface
		1.767	0.511	1.0002	Near surface ,
6	1.056	1.116	0.060	1.0035	Near bed ,
		1.345	0.289	1.0032	Below interface
		1.415	0.359	1.0002	Above interface
		1.570	0.514	1.0002	Near surface .

Table: 4 - AS - 10

Time since test started: 52 Hours

Section	Bed Reading, Ft.	Depth Reading, Ft.	Depth Ft.	Specific Gravity, S	Remarks
2	1.233	1.293 1.663 1.740	0.060 0.420 0.497	1.0035 1.0035 1.0005	Near bed, Below interface Near surface.
3	1.291	1.351 1.681 1.751 1.797	0.060 0.390 0.460 0.506	1.0035 1.0035 1.0003 1.0003	Near bed. Below interface Above interface Near surface.
4	1.290	1.350 1.640 1.720 1.795	0.060 0.350 0.430 0.505	1.0035 1.0035 1.0002 1.0002	Near bed. Below interface Above interface Near surface.
5	1.256	1.316 1.566 1.636 1.766	0.060 0.310 0.380 0.510	1.0033 1.0033 1.0002 1.0002	Near bed, Below interface Above interface Near surface,
6	1.055	1.115 1.355 1.435 1.569	0.060 0.300 0.380 0.514	1.0033 1.0033 1.0002 1.0002	Near bed. Below interface Above interface Near surface.

Table: 4 - AS - 11

Time since test started: 58 Hours

Section	Bed Reading, Ft.	Depth Reading, Ft.	Depth Ft.	Specific Gravity, S	Remarks
2	1.233	1.293 1.673 1.732	0.060 0.440 0.499	1.0031 1.0031 1.0022	Near bed, Below interface Near surface.
3	1.291	1.351 1.691 1.751 1.792	0.060 0.400 0.460 0.501	1.0032 1.0030 1.0003 1.0003	Near bed, Below interface Near surface.
4	1.290	1.350 1.650 1.720 1.793	0.060 0.360 0.430 0.503	1.0029 1.0026 1.0002 1.0002	Near bed, Below interface Near surface.
5	1.256	1.316 1.576 1.646 1.761	0.060 0.320 0.390 0.505	1.0032 1.0029 1.0002 1.0002	Near bed, Below interface Near surface.
6	1.055	1.115 1.365 1.445 1.563	0.060 0.310 0.390 0.508	1.0029 1.0026 1.0002 1.0002	Near bed. Below interface Near surface.

Table: 4 - AS - 12

Time since test started: 70 Hours

Section	Bed Reading . Ft.	Depth Reading , Ft.	Depth Ft.	Specific Gravity . S	Remarks
2	1.233	1.293 1.728	0.060 0.488	1.0026 1.0026	Near bed , Near surface .
3	1.291	1.351 1.790	0.060 0.499	1.0029 1.0026	Near bed . Near surface .
4	1.290	1.350 1.680 1.740 1.788	0.060 0.390 0.450 0.498	1.0029 1.0029 1.0002 1.0002	Near bed , Near surface.
5	1.256	1.316 1.586 1.656 1.756	0.060 0.330 0.400 0.500	1.0030 1.0029 1.0002 1.0002	Near bed. Near surface .
6	1.055	1.115 1.375 1.445 1.560	0.060 0.320 0.390 0.505	1.0029 1.0025 1.0003 1.0002	Near bed . Near surface .

Test Run 5

General Data.

Material Used: Aluminium silicate

Flume Slope: 1 in 360

Sluice Gate Opening: 5"

Test Started: 12:00 Noon on 25.8.64

Duration of Test: 72 Hours

Observation Time: 2, 4, 6, 10, 22, 24, 28, 34, 46, 52, 58, and 68 hours after the start of the test.

Data of Syphons.

Syphon No.	Used at Test Section.	Bed Reading. Ft.	Bed Reading Corrected for Syphon Diameter.
1	2	1.243	1.233
2	3	1.301	1.291
3	4	1.300	1.290
4	5	1.266	1.256
5	6	1.065	1.055

Flow Data.

Flow over weir - Free

Gauge reading upstream of weir = 0.803 Feet.

Reading for no flow = 0.587 Feet.

∴ Head over weir = 0.216 Feet.

From flow curve for free flowing weir (Appendix A)

$Q = 0.032$ C.F.S.

OBSERVATIONS OF DENSITY LAYER FRONT.

Test Run 5

Serial No. of Observation.	Observed Between Sections.	Distance Travelled, Ft.	Time Taken, Secs.	Average Velocity, Ft./Secs.
1	3 and 4	20	190	0.105
2	4 and 5	20	188	0.106
3	5 and 6	10	92	0.109

Overall average velocity = 0.106 Ft./Sec.

Shape of Front.

Round nosed having its head bigger than general thickness following it and lifted up above the flume bed slightly.

Refer photographs of density layer front taken through windows at test sections 2, 3, 4, and 5 respectively.

PROFILE MEASUREMENTS

Test Run 5

Table: 5 - P - 1

Time since test started: 2 Hours.

Section	Bed Reading Ft.	Density Layer Reading Ft.	Reading of Interlayer Ft.	*Top Reading Ft.	d Col. 3- Col. 2 Ft.	d_1 Col. 4- Col. 3	D Col. 5- Col. 2 Ft.	S_o	T °F.	H Ft.
1	2	3	4	5	6	7	8	9	10	11
1	0.072	-	-	0.611	-	-	0.539			
2	0.236	0.483	0.767	0.809	0.247	0.284	0.573	1.0075	66	0.216
3	0.071	0.387	0.666	0.708	0.316	0.279	0.637			
4	0.104	0.476	0.743	0.797	0.372	0.267	0.693			
5	0.122	0.556	0.839	0.889	0.434	0.283	0.767			
6	0.098	-	-	0.899	-	-	0.801			

Where d = Thickness of density layer in feet.

d_1 = Thickness of interlayer in feet.

D = Total depth of flow in feet.

S_o = Specific gravity of water flowing over weir.

S = Specific gravity of water drawn from any depth at test sections.

T = Temperature of water flowing over weir in °F.

H = Head over weir in feet.

*Top readings went on decreasing consistently throughout the test because there was a leakage from the pump at the tail end of the flume.

NOTE: These symbols will have the same meaning throughout all profile measurements.

Table: 5 - P - 2

Time since test started: 4 Hours

Section.	Bed Reading. Ft.	Density Layer Reading. Ft.	*Top Reading. Ft.	d Col. 3- Col. 2 Ft.	D Col. 4- Col. 2 Ft.	S_o	T $^oF.$	H Ft.
1	2	3	4	5	6	7	8	9
1	0.072	-	0.610	-	0.538			
2	0.236	0.655	0.809	0.419	0.573	1.0065	69.0	0.216
3	0.071	0.554	0.708	0.483	0.637			
4	0.104	0.635	0.797	0.531	0.693			
5	0.122	0.721	0.888	0.599	0.766			
6	0.098	-	0.898	-	0.800			

Table: 5 - P - 3

Time since test started: 6 Hours

1	0.072	-	0.609	-	0.537			
2	0.236	0.670	0.807	0.434	0.571	1.0060	70.0	0.212
3	0.071	0.574	0.707	0.503	0.636			
4	0.104	0.661	0.794	0.557	0.690			
5	0.122	0.756	0.888	0.634	0.766			
6	0.098	-	0.897	-	0.799			

Table: 5 - P - 4

Time since test started: 10 Hours

1	0.072	-	0.607	-	0.535			
2	0.236	0.682	0,807	0.446	0.571	1.0054	71.5	0.214
3	0.071	0.578	0.707	0.507	0.636			
4	0.104	0.677	0.794	0.573	0.690			
5	0.122	0.773	0.885	0.651	0.763			
6	0.098	-	0.896	-	0.798			

Table: 5 - P - 5

Time since test started: 22 Hours

Section.	Bed Reading Ft.	Density Layer Reading. Ft.	*Top Reading. Ft.	d Col. 3-Col. 2 Ft.	D Col. 4-Col. 2 Ft.	S_o	T $^oF.$	H Ft.
1	2	3	4	5	6	7	8	9
1	0.072	-	0.601	-	0.529			
2	0.236	0.698	0.802	0.462	0.566	1.0050	73.5	0.210
3	0.071	0.604	0.700	0.533	0.629			
4	0.104	0.677	0.788	0.573	0.684			
5	0.122	0.777	0.881	0.655	0.759			
6	0.098	-	0.889	-	0.791			

Table: 5 - P - 6

Time since test started: 24 Hours

1	0.072	-	0.600	-	0.528			
2	0.236	0.699	0.799	0.463	0.563	1.0047	73.0	0.211
3	0.071	0.605	0.700	0.534	0.629			
4	0.104	0.689	0.786	0.585	0.682			
5	0.122	0.779	0.877	0.657	0.755			
6	0.098	-	0.888	-	0.790			

Table: 5 - P - 7

Time since test started: 28 Hours

1	0.072	-	0.598	-	0.526			
2	0.236	0.700	0.798	0.464	0.562	1.0045	75.0	0.211
3	0.071	0.606	0.698	0.535	0.627			
4	0.104	0.690	0.785	0.586	0.681			
5	0.122	0.789	0.876	0.667	0.754			
6	0.098	-	0.886	-	0.788			

Table: 5 - P - 8

Time since test started: 34 Hours

Section.	Bed Reading. Ft.	Density Layer Reading. Ft.	*Top Reading. Ft.	d Col. 3- Col. 2 Ft.	D Col. 4- Col. 2 Ft.	S_o	T °F.	H Ft.
1	2	3	4	5	6	7	8	9
1	0.072	-	0.594	-	0.522			
2	0.236	0.704	0.796	0.468	0.560	1.0043	75.5	0.211
3	0.071	0.608	0.693	0.537	0.622			
4	0.104	0.699	0.782	0.588	0.678			
5	0.122	0.791	0.871	0.669	0.749			
6	0.098	-	0.881	-	0.783			

Table: 5 - P - 9

Time since test started: 46 Hours

1	0.072	-	0.588	-	0.516			
2	0.236	0.706	0.787	0.470	0.551	1.0040	75.5	0.207
3	0.071	0.610	0.684	0.539	0.613			
4	0.104	0.698	0.772	0.594	0.668			
5	0.122	0.797	0.865	0.675	0.743			
6	0.098	-	0.875	-	0.777			

Table: 5 - P - 10

Time since test started: 52 Hours

1	0.072	-	0.584	-	0.512			
2	0.236	0.708	0.784	0.472	0.548	1.0038	77.0	0.207
3	0.071	0.611	0.681	0.540	0.610			
4	0.104	0.701	0.768	0.597	0.664			
5	0.122	0.800	0.863	0.678	0.741			
6	0.098	-	0.872	-	0.774			

Table: 5 - P - 11

Time since test started: 58 Hours

Section.	Bed Reading. Ft.	Density Layer Reading. Ft.	*Top Reading. Ft.	d Col. 3-Col. 2 Ft.	D Col. 4-Col. 2 Ft.	S_o	T °F.	H Ft.
1	2	3	4	5	6	7	8	9
1	0.072	-	0.580	-	0.508			
2	0.236	0.701	0.788	0.473	0.552	1.0035	77.5	0.206
3	0.071	0.601	0.680	0.530	0.609			
4	0.104	0.694	0.765	0.590	0.661			
5	0.122	0.788	0.857	0.666	0.735			
6	0.098	-	0.866	-	0.768			

Table: 5 - P - 12

Time since test started: 68 Hours

1	0.072	-	0.569	-	0.497			
2	0.236	0.699	0.770	0.463	0.534	1.0032	77.0	0.205
3	0.071	0.596	0.668	0.525	0.597			
4	0.104	0.683	0.756	0.579	0.652			
5	0.122	0.777	0.850	0.655	0.728			
6	0.098	-	0.860	-	0.762			

Table: 5 - P - 13

Reading of deposits at bed of flume.

Section.	Bed Reading. Ft.	Reading of Deposits at Bed. Ft.	Thickness of Deposits. Ft.	Remarks.
1	0.072	0.077	0.005	These readings were taken 24
2	0.236	0.241	0.005	hours after the test was stopped
3	0.071	0.075	0.004	and the flume drained out.
4	0.104	0.109	0.005	
5	0.122	0.129	0.007	
6	0.098	0.105	0.007	

MEASUREMENTS OF DEPOSITS AT FLUME BED

Test Run 5

Plate No.	Laid at Section.	Weight of Plate, Grams	Total Weight. Grams	Weight of Deposits. Grams	Area of Plate, Inches	Time for Deposits, T+td Hours	Deposits per □ inch. Grams	Net Deposits/ Inch^2 in T Hours Grams
14	2	3.76	6.18	2.42	4.00	72+td	0.6050	0.5845
1	2	4.26	5.40	1.14	4.50	48+td	0.2533	0.2247
4	2	4.38	5.32	0.94	4.50	40+td	0.2089	0.1803
7	2	4.32	4.65	0.33	4.50	16+td	0.0733	0.0447
11	2	3.80	3.91	0.11	3.84	0+td	0.0286	0.0000
21	4	3.24	5.63	2.39	4.00	72+td	0.5975	0.5689
2	4	4.22	5.26	1.04	4.50	48+td	0.2311	0.2106
5	4	4.32	5.15	0.83	4.50	40+td	0.1844	0.1639
8	4	4.35	4.72	0.37	4.50	16+td	0.0822	0.0617
12	4	3.80	3.88	0.08	3.90	0+td	0.0205	0.0000
18	6	3.71	6.04	2.33	4.00	72+td	0.5825	0.5646
3	6	4.30	6.04	1.74	4.47	48+td	0.3893	0.3714
6	6	4.28	5.26	0.98	4.47	40+td	0.2192	0.2013
9	6	4.28	4.72	0.44	4.50	16+td	0.0978	0.0799
13	6	3.80	3.87	0.07	3.90	0+td	0.0179	0.0000

Where T = Time in hours for which material was depositing on the plate.

td = Time in hours for which the flume was being drained out, starting from the stopping of the test.

VELOCITY MEASUREMENTS

Test Run 5

Section of observation: 4

Distance from upstream sluice gate: 65 Feet.

Table: 5 - V - 1

Time since test started: 2 Hours.

Position From Bed Ft.	Distance Travelled Inches	Time Taken Secs.	Velocity Inch/sec.	Remarks
0.693	-2	114.8	-0.0017	Surface.
0.651	-2	42.2	-0.0475	
0.455	-2	37.0	-0.0541	
0.372	-	-	0.0000	Interface.
0.186	By similar calculations as shown in Test Run 3.		0.5780	Maximum velocity of lower layer.
0.000	-	-	0.0000	Bed.

Table: 5 - V - 2

Time since test started: 4 Hours.

Position From Bed Ft.	Distance Travelled Inches	Time Taken Secs.	Velocity Inch/sec.	Remarks
0.693	-	-	0.0000	Surface.
0.610	-2	65.6	-0.0305	
0.531	-	-	0.0000	Interface.
0.266	By similar calculations as shown in Test Run 3.		0.3710	Maximum velocity of lower layer.
0.000	-	-	0.0000	Bed.

Table: 5 - V - 3

Time since test started: 6 Hours.

Position From Bed Ft.	Distance Travelled Inches	Time Taken Secs.	Velocity Inch/sec.	Remarks
0.690	-	-	0.0000	Surface.
0.628	-2	59.8	-0.0330	
0.557	-	-	0.0000	Interface.
0.278	By similar velocity calculations as shown in Test Run 3.		0.3260	Maximum velocity of lower layer.
0.000	-	-	0.0000	Bed.

Table: 5 - V - 4

Time since test started: 10 Hours.

Position From Bed Ft.	Distance Travelled Inches	Time Taken Secs.	Velocity Inch/sec.	Remarks
0.690	-1	63.5	-0.016	Surface.
0.615	-2	45.0	-0.044	
0.573	-	-	0.000	Interface.
0.286	By similar calculations as shown in Test Run 3.		0.320	Maximum velocity of lower layer.
0.000	-	-	0.000	Bed.

Table: 5 - V - 5

Time since test started: 22 Hours.

Position From Bed Ft.	Distance Travelled Inches	Time Taken Secs.	Velocity Inch/sec.	Remarks
0.684	-1	142.0	-0.007	Surface.
0.594	-2	61.6	-0.032	
0.573	-	-	0.000	Interface.
0.286	By similar calculations as shown in Test Run 3.		0.267	Maximum velocity of lower layer.
0.000	-	-	0.000	Bed.

Table: 5 - V - 6

Time since test started: 24 Hours.

Position From Bed Ft.	Distance Travelled Inches	Time Taken Secs.	Velocity Inch/sec.	Remarks
0.682	-2	95.6	-0.021	Surface.
0.661	-2	89.2	-0.022	
0.585	-	-	0.000	Interface.
0.293	By similar calculations as shown in Test Run 3.		0.301	Maximum velocity of lower layer.
0.000	-	-	0.000	Bed.

Table: 5 - V - 7

Time since test started: 28 Hours.

Position From Bed Ft.	Distance Travelled Inches	Time Taken Secs.	Velocity Inch/sec.	Remarks
0.681	-2	90.0	-0.022	Surface.
0.619	-1	40.0	-0.025	
0.586	-	-	0.000	Interface.
0.293	By similar calculations as shown in Test Run 3.		0.302	Maximum velocity of lower layer.
0.000	-	-	0.000	Bed.

Table: 5 - V - 8

Time since test started: 34 Hours.

Position From Bed Ft.	Distance Travelled Inches	Time Taken Secs.	Velocity Inch/sec.	Remarks
0.678	-2	124.0	-0.016	Surface.
0.636	-2	63.6	-0.031	
0.588	-	-	0.000	Interface.
0.294	By similar calculations as shown in Test Run 3.		0.299	Maximum velocity of lower layer.
0.000	-	-	0.000	Bed.

Table: 5 - V - 9

Time since test started: 46 Hours.

Position From Bed Ft.	Distance Travelled Inches	Time Taken Secs.	Velocity Inch/sec.	Remarks
0.668	-2	92.0	-0.022	Surface.
0.626	-2	61.2	-0.033	
0.594	-	-	0.000	Interface.
0.297	By similar calculations as shown in Test Run 3.		0.286	Maximum velocity of lower layer.
0.000	-	-	0.000	Bed.

Table: 5 - V - 10

Time since test started: 52 Hours.

Position From Bed Ft.	Distance Travelled Inches	Time Taken Secs.	Velocity Inch/sec.	Remarks
0.664	-2	45.0	-0.044	Surface.
0.622	-2	61.2	-0.033	
0.597	-	-	0.000	Interface.
0.298	By similar calculations as shown in Test Run 3.		0.286	Maximum velocity of lower layer.
0.000	-	-	0.000	Bed.

Table: 5 - V - 11

Time since test started: 58 Hours.

Position From Bed Ft.	Distance Travelled Inches	Time Taken Secs.	Velocity Inch/sec.	Remarks
0.661	-2	33.8	-0.059	Surface.
0.640	-2	36.8	-0.054	
0.611	-2	52.4	-0.038	
0.590	-	-	0.000	Interface.
0.295	By similar calculations as shown in Test Run 3.		0.287	Maximum velocity of lower layer.
0.000	-	-	0.000	Bed.

Table: 5 - V - 12

Time since test started: 68 Hours.

Position From Bed Ft.	Distance Travelled Inches	Time Taken Secs.	Velocity Inch/sec.	Remarks
0.652	-2	47.2	-0.035	Surface.
0.631	-2	73.2	-0.027	
0.579	-	-	0.000	Interface.
0.289	By similar calculations as shown in Test Run 3.		0.284	Maximum velocity of lower layer.
0.000	-	-	0.000	Bed.

MEASUREMENTS FOR ALUMINIUM SILICATE CONCENTRATIONS

Test Run 5

Table: 5 - AS - 1

Time since test started: 2 Hours

Section	Bed Reading. Ft.	Depth Reading. Ft.	Depth Ft.	Specific Gravity. S	Remarks
2	1.233	1.293	0.060	1.0064	Near bed.
		1.503	0.270	1.0050	Below interface
		1.743	0.510	1.0006	Below interlayer
		1.793	0.560	1.0000	Near surface.
3	1.291	1.351	0.060	1.0064	Near bed.
		1.611	0.320	1.0048	Below interface
		1.901	0.610	1.0009	Below interlayer
		1.910	0.619	1.0000	Near surface.
4	1.290	1.350	0.060	1.0064	Near bed.
		1.659	0.369	1.0041	Below interface
		1.369	0.579	1.0008	Below interlayer
		1.961	0.671	1.0000	Near surface.
5	1.256	1.316	0.060	1.0064	Near bed.
		1.716	0.460	1.0048	Below interface
		1.992	0.736	1.0000	Near surface.
6	1.055	1.115	0.060	1.0064	Near bed.
		1.465	0.410	1.0048	Below interface
		1,851	0.796	1.0000	Near surface.

Table: 5 - AS - 2

Time since test started: 4 Hours

Section	Bed Reading, Ft.	Depth Reading, Ft.	Depth Ft.	Specific Gravity, S	Remarks
2	1.233	1.293 1.645 1.765	0.060 0.412 0.532	1.0064 1.0035 1.0000	Near bed. Below interface Near surface,
3	1.291	1.351 1.751 1.870	0.060 0.460 0.579	1.0063 1.0045 1.0000	Near bed. Below interface Near surface.
4	1.290	1.350 1.810 1.926	0.060 0.520 0.636	1.0064 1.0036 1.0000	Near bed. Below interface Near surface.
5	1.256	1.316 1.746 1.948	0.060 0.490 0.692	1.0064 1.0052 1.0000	Near bed. Below interface Near surface,
6	1.055	1.115 1.605 1.840	0.060 0.550 0.785	1.0064 1.0052 1.0000	Near bed. Below interface Near surface.

Table: 5 - AS - 3

Time since test started: 6 hours

Section	Bed Reading. Ft.	Depth Reading. Ft.	Depth Ft.	Specific Gravity. S	Remarks.
2	1.233	1.293 1.629 1.765	0.060 0.396 0.532	1.0062 1.0045 1.0000	Near bed. Below interface Near surface.
3	1.291	1.351 1.771 1.870	0.060 0.480 0.579	1.0062 1.0040 1.0000	Near bed. Below interface Near surface.
4	1.290	1.350 1.840 1.926	0.060 0.550 0.636	1.0060 1.0030 1.0000	Near bed. Below interface Near surface.
5	1.256	1.316 1.866 1.948	0.060 0.610 0.692	1.0064 1.0035 1.0000	Near bed. Below interface Near surface.
6	1.055	1.115 1.711 1.841	0.060 0.656 0.786	1.0062 1.0033 1.0000	Near bed. Below interface. Near surface.

Table: 5 - AS - 4

Time since test started: 10 Hours

Section	Bed Reading, Ft.	Depth Reading, Ft.	Depth Ft.	Specific Gravity, S	Remarks
2	1.233	1.293 1.647 1.768	0.060 0.414 0.535	1.0054 1.0041 1.0001	Near bed. Below interface. Near surface.
3	1.291	1.351 1.778 1.876	0.060 0.487 0.585	1.0059 1.0041 1.0001	Near bed. Below interface Near surface.
4	1.290	1.350 1.826 1.960	0.060 0.536 0.676	1.0054 1.0037 1.0001	Near bed. Below interface Near surface.
5	1.256	1.316 1.864 1.957	0.060 0.608 0.701	1.0058 1.0037 1.0001	Near bed, Below interface. Near surface.
6	1.055	1.115 1.714 1.823	0.060 0.659 0.768	1.0055 1.0038 1.0001	Near bed. Below interface Near surface.

Table: 5 - AS - 5

Time since test started: 22 Hours

Section	Bed Reading, Ft.	Depth Reading, Ft.	Depth Ft.	Specific Gravity, S	Remarks
2	1.233	1.293 1.658 1.763	0.060 0.425 0.530	1.0051 1.0026 1.0001	Near bed. Below interface Near surface.
3	1.291	1.351 1.770 1.871	0.060 0.479 0.580	1.0049 1.0036 1.0001	Near bed. Below interface Near surface.
4	1.290	1.350 1.836 1.943	0.060 0.546 0.653	1.0051 1.0027 1.0001	Near bed. Near surface.
5	1.256	1.316 1.869 1.946	0.060 0.613 0.690	1.0051 1.0026 1.0001	Near bed. Below interface Near surface.
6	1.055	1.115 1.706 1.837	0.060 0.651 0.782	1.0052 1.0031 1.0001	Near bed. Below interface Near surface.

Table: 5 - AS - 6

Time since test started: 24 Hours

Section	Bed Reading, Ft.	Depth Reading, Ft.	Depth Ft.	Specific Gravity, S	Remarks
2	1.233	1.293 1.660 1.776	0.060 0.427 0.543	1.0050 1.0030 1.0001	Near bed. Below interface Near surface.
3	1.291	1.351 1.766 1.905	0.060 0.475 0.614	1.0046 1.0035 1.0001	Near bed. Below interface Near surface.
4	1.290	1.350 1.832 1.952	0.060 0.542 0.662	1.0046 1.0029 1.0001	Near bed. Below interface Near surface.
5	1.256	1.316 1.863 1.971	0.060 0.607 0.715	1.0051 1.0028 1.0001	Near bed. Below interface Near surface.
6	1.055	1.115 1.717 1.845	0.060 0.662 0.790	1.0046 1.0030 1.0001	Near bed. Below interface Near surface.

Table: 5 - AS - 7

Time since test started: 28 Hours

Section	Bed Reading. Ft.	Depth Reading. Ft.	Depth Ft.	Specific Gravity. S	Remarks
2	1.233	1.293 1.652 1.776	0.060 0.419 0.543	1.0048 1.0025 1.0001	Near bed. Below interface Near surface.
3	1.291	1.351 1.764 1.905	0.060 0.473 0.614	1.0045 1.0030 1.0001	Near bed. Below interface Near surface.
4	1.290	1.350 1.830 1.952	0.060 0.540 0.662	1.0046 1.0030 1.0001	Near bed. Near surface.
5	1.256	1.316 1.865 1.971	0.060 0.609 0.715	1.0046 1.0026 1.0001	Near bed. Near surface.
6	1.055	1.115 1.721 1.854	0.060 0.666 0.789	1.0046 1.0024 1.0001	Near bed. Near surface.

Table: 5 - AS - 8

Time since test started: 34 Hours

Section	Bed Reading. Ft.	Depth Reading. Ft.	Depth Ft.	Specific Gravity. S	Remarks
2	1.233	1.293 1.660 1.780	0.060 0.427 0.547	1.0043 1.0025 1.0001	Near bed. Below interface Near surface.
3	1.291	1.351 1.781 1.877	0.060 0.490 0.586	1.0044 1.0032 1.0001	Near bed. Below interface Near surface.
4	1.290	1.350 1.834 1.950	0.060 0.544 0.660	1.0043 1.0028 1.0001	Near bed. Below interface Near surface.
5	1.256	1.316 1.868 1.986	0.060 0.613 0.730	1.0046 1.0028 1.0001	Near bed. Near interface Near surface.
6	1.055	1.115 1.720 1.840	0.060 0.665 0.785	1.0043 1.0030 1.0001	Near bed. Near interface Near surface.

Table: 5 - AS - 9

Time since test started: 46 Hours

Section	Bed Reading. Ft.	Depth Reading. Ft.	Depth Ft.	Specific Gravity. S	Remarks
2	1.233	1.293 1.660 1.771	0.060 0.427 0.538	1.0043 1.0018 1.0001	Near bed. Near surface.
3	1.291	1.351 1.770 1.875	0.060 0.479 0.584	1.0039 1.0024 1.0001	Near bed. Below interface Near surface.
4	1.290	1.350 1.836 1.946	0.060 0.546 0.656	1.0043 1.0025 1.0001	Near bed. Near surface.
5	1.256	1.316 1.868 1.978	0.060 0.612 0.722	1.0043 1.0022 1.0001	Near bed. Below interface Near surface,
6	1.055	1.115 1.723 1.835	0.060 0.668 0.780	1.0040 1.0021 1.0001	Near bed. Near surface.

Table: 5 - AS - 10

Time since test started: 52 Hours

Section	Bed Reading. Ft.	Depth Reading. Ft.	Depth Ft.	Specific Gravity. S	Remarks
2	1.233	1.293	0.060	1.0039	Near bed.
		1.715	0.482	1.0021	Below density layer top.
		1.775	0.542	1.0001	Near surface.
3	1.291	1.351	0.060	1.0039	Near bed.
		1.797	0.506	1.0021	Below density layer top.
		1.895	0.604	1.0001	Near surface.
4	1.290	1.350	0.060	1.0039	Near bed.
		1.835	0.544	1.0021	Below density layer top.
		1.899	0.609	1.0001	Near surface.
5	1.256	1.316	0.060	1.0039	Near bed.
		1.865	0.609	1.0021	Below density layer top.
		1.978	0.722	1.0001	Near surface.
6	1.055	1.115	0.060	1.0033	Near bed.
		1.697	0.642	1.0020	
		1.825	0.770	1.0001	Near surface.

Table: 5 - AS - 11

Time since test started: 58 Hours

Section	Bed Reading, Ft.	Depth Reading, Ft.	Depth Ft.	Specific Gravity, S	Remarks
2	1.233	1.293 1.662 1.710	0.060 0.429 0.477	1.0033 1.0015 1.0001	Near bed. Near interface Near surface.
3	1.291	1.351 1.785 1.888	0.060 0.494 0.597	1.0033 1.0020 1.0001	Near bed. Below interface Near surface.
4	1.290	1.350 1.843 1.935	0.060 0.553 0.645	1.0032 1.0019 1.0001	Near bed. Near interface Near surface.
5	1.256	1.316 1.861 1.967	0.060 0.605 0.711	1.0034 1.0020 1.0001	Near bed. Below interface Near surface.
6	1.055	1.115 1.714 1.820	0.060 0.659 0.765	1.0033 1.0019 1.0001	Near bed. Below interface Near surface.

Table: 5 - AS - 12

Time since test started: 68 Hours

Section	Bed Reading, Ft.	Depth Reading, Ft.	Depth Ft.	Specific Gravity, S	Remarks
2	1.233	1.293 1.654 1.752	0.060 0.421 0.519	1.0032 1.0012 1.0001	Near bed. Near surface.
3	1.291	1.351 1.773 1.878	0.060 0.482 0.587	1.0032 1.0019 1.0001	Near bed. Near surface.
4	1.290	1.350 1.836 1.922	0.060 0.546 0.632	1.0032 1.0018 1.0001	Near bed. Near surface.
5	1.256	1.316 1.854 1.962	0.060 0.598 0.706	1.0032 1.0021 1.0001	Near bed. Near surface.
6	1.055	1.115 1.715 1.809	0.060 0.660 0.754	1.0032 1.0018 1.0001	Near bed. Near surface.

TEST RUN 6

General Data

Material Used: Salt

Dye Used: Fluoresene

Flume Slope: 1 in. 360

Sluice Gate Opening: 5"

Test Started: 12:00 Noon on 7.9.64

Duration of Test: 25 Hours

Observation Time: 2, 4, 6, 8, 10, and 24 hours after the test started.

Data of Conductivity Probes.

Conductivity Probe No.	Attenuator Reading.	Range Set.	Used at Section.	Bed Reading Ft.
2	x20	0 to 2% salinity Concentration by weight.	2	0.967
3	x50		3	1.012
1	x100		4	0.891
5	x100		5	1.218
6	x100		6	0.947

Flow Data.

Flow over weir - Free

Gauge reading upstream of weir = 0.709 Feet

Reading for no flow = 0.587 Feet

Head over weir = 0.122 Feet

From flow curve for free flowing weir (Appendix A)

$$Q = 0.007 \text{ C.F.S.}$$

OBSERVATIONS OF DENSITY LAYER FRONT .

Test Run 6

Serial No. of Observation.	Observed Between Sections.	Distance Travelled. Ft.	Time Taken. Secs.	Average Velocity Ft./Secs.
1	3 and 4	20	180	0.111
2	4 and 5	20	187	0.107
3	5 and 6	10	93	0.107
4	6 and D/S sluice gate	5	47	0.106

Overall Average Velocity = 0.108 Ft./Sec.

Shape of Front .

Round nosed having head bigger than its general thickness following it and lifted up slightly above the flume bed.

PROFILE MEASUREMENTS

Test Run 6

Table: 6 - P - 1

Time since test started: 2 Hours

Section.	Bed Reading. Ft.	Density Layer Reading. Ft.	*Top Reading. Ft.	d Col. 3- Col. 2. Ft.	D Col. 4- Col. 2. Ft.	λ_1	C_0 %	H Ft.
1	2	3	4	5	6	7	8	9
1	0.072	-	0.573	-	0.501	⊕		
2	0.236	0.494	0.773	0.258	0.537	10	2.080	0.122
3	0.071	0.383	0.673	0.312	0.602			
4	0.104	0.483	0.758	0.379	0.654	T= 62°F		
5	0.122	0.546	0.854	*0.424	0.732			
6	0.098	-	0.862	-	0.764			

Where d = Thickness of density layer in feet

D = Total depth of flow in feet

λ_1 - Deflection of recorder for water flowing over weir

λ = Deflection of recorder

C_0 = Concentration percent by weight, taken from λ-c plot of the probe used

H = Head over weir in feet

*Top readings went on decreasing consistently throughout the test, because there was a leakage from the pump at the tail end of the flume.

⊕Probe No. 2 was used. Refer Appendix B for its calibration curve. Salinity of water in the beginning of the test was 2.08% by weight.

*Not well defined as yet.

NOTE: These signs will have the same interpretation throughout all profile measurements.

Table: 6 - P - 2

Time since test started: 4 Hours

Section.	Bed Reading. Ft.	Density Layer Reading. Ft.	*Top Reading. Ft.	d Col. 3-Col. 2, Ft.	D Col. 4-Col. 2, Ft.	Λ_1	C_0 %	H Ft.
1	2	3	4	5	6	7	8	9
1	0.072	-	0.572	-	0.500			
2	0.236	0.630	0.772	0.394	0.536			
3	0.071	0.539	0.672	0.509	0.601	10	2.080	0.120
4	0.104	0.639	0.757	0.535	0.653			
5	0.122	0.770	0.853	0.648	0.731	T = 62.5°F		
6	0.098	-	0.861	-	0.763			

Table: 6 - P - 3

Time since test started: 6 Hours

1	0.072	-	0.572	-	0.500			
2	0.236	0.689	0.772	0.453	0.536			
3	0.071	0.588	0.672	0.517	0.601	10	2.080	0.120
4	0.104	0.674	0.757	0.567	0.653			
5	0.122	0.784	0.853	0.660	0.731	T = 64°F		
6	0.098	-	0.861	-	0.763			

Table: 6 - P - 4

Time since test started: 8 Hours

1	0.072	-	0.571	-	0.499			
2	0.236	0.717	0.771	0.481	0.535			
3	0.071	0.614	0.671	0.543	0.600	10	2.080	0.120
4	0.104	0.699	0.756	0.595	0.652			
5	0.122	0.795	0.852	0.673	0.730	T = 65°F		
6	0.098	-	0.860	-	0.762			

Table: 6 - P - 5

Time since test started: 10 Hours

Section.	Bed Reading. Ft.	Density Layer Reading. Ft.	*Top Reading, Ft.	d Col. 3-Col. 2, Ft.	D Col. 4-Col. 2, Ft.	Ω_1	C_0 %	H Ft.
1	2	3	4	5	6	7	8	9
1	0.072	-	0.571	-	0.499			
2	0.236	0.729	0.771	0.493	0.535			
3	0.071	0.621	0.671	0.550	0.600	10	2.080	0.117
4	0.104	0.706	0.756	0.602	0.652			
5	0.122	0.802	0.852	0.680	0.730	T= 66°F		
6	0.098	-	0.860	-	0.762			

Table: 6 - P - 6

Time since test started: 24 Hours

Section.	Bed Reading. Ft.	Density Layer Reading. Ft.	*Top Reading, Ft.	d Col. 3-Col. 2, Ft.	D Col. 4-Col. 2, Ft.	Ω_1	C_0 %	H Ft.
1	0.072	-	0.563	-	0.491			
2	0.236	0.734	0.763	0.498	0.527			
3	0.071	0.626	0.663	0.555	0.592	9.5	1.780	0.113
4	0.104	0.711	0.748	0.607	0.644			
5	0.122	0.807	0.844	0.685	0.722	T = 66°F		
6	0.098	-	0.852	-	0.754			

VELOCITY MEASUREMENTS

Test Run 6

Section of observation: 3

Distance from upstream sluice gate: 45 Feet

Table: 6 - V - 1

Time since start of test: 2 Hours

Position From Bed. Ft.	Distance Travelled. Inches,	Time Taken, Secs.	Velocity. Inch/Sec.	Remarks,
0.602	-2	70	-0.029	Surface.
0.519	-2	22.4	-0.089	Flow upwards.
0.395	-2	14.4	-0.139	" "
0.343	-2	15.6	-0.128	" "
0.312	-2	19.8	-0.101	Interface.
0.125	2	33.4	0.060	Flow downwards
0.0625	2	25.8	0.077	" "
0.021	2	84.0	0.024	" "
0	-	-	0.000	Bed.

Table: 6 - V - 2

Time since start of test: 4 Hours

Position From Bed. Ft.	Distance Travelled. Inches,	Time Taken, Secs.	Velocity. Inch/Sec.	Remarks,
0.601	-2	70.8	-0.028	Surface, Flow upwards.
0.518	-2	28.6	-0.070	Flow upwards.
0.455	-2	19.0	-0.105	" "
0.301	-2	70.4	-0.028	" "
0.208	2	20.2	0.099	Flow downwards
0,083	2	14.6	0.137	" "
0	-	-	0.000	Bed.

Table: 6 - V - 3

Time since start of test: 6 Hours

Position From Bed. Ft.	Distance Travelled. Inches,	Time Taken, Secs.	Velocity. Inch/Sec.	Remarks,
0.601	-2	73.6	-0.027	Surface, Flow upwards.
0.496	-2	43.2	-0.046	Flow upwards.
0.434	-2	30.2	-0.066	" "
0.250	2	31	0.064	Flow downwards
0.021	2	15.4	0.130	" "
0	-	-	0	Bed.

Table: 6 - V - 4

Time since start of test: 8 Hours

Position From Bed. Ft.	Distance Travelled. Inches.	Time Taken Secs.	Velocity. Inch/Sec.	Remarks.
0.600	-2	84	-0.024	Surface, Flow upwards.
0.564	-2	74.8	-0.027	Flow upwards.
0.480	-	-	0.000	No flow.
0.333	2	45.8	0.044	Flow downwards
0.167	2	16.6	0.121	" "
0	-	-	0	Bed.

Table: 6 - V - 5

Time since start of test: 10 Hours

Position From Bed. Ft.	Distance Travelled. Inches.	Time Taken Secs.	Velocity. Inch/Sec.	Remarks.
0.600	-	-	0	Surface.
0.508	-1	76.2	-0.0131	Flow upwards.
0.383	-1	46	-0.0217	" "
0.250	2	21.2	0.0943	Flow downwards
0.083	2	18	0.1112	" "
0	-	-	0	Bed.

Table: 6 - V - 6

Time since start of test: 24 Hours

Position From Bed. Ft.	Distance Travelled. Inches.	Time Taken Secs.	Velocity. Inch/Sec.	Remarks.
0.592	-1	93.2	-0.0107	Surface, flow upwards.
0.534	-1	35.3	-0.0283	Flow upwards.
0.333	2	30.2	0.0662	Flow downwards
0.125	2	37.6	0.0532	" "
0	-	-	0	Bed.

SALINITY CONCENTRATION MEASUREMENTS

Test Run 6

Table: 6 - S - 1

Time since test started: 2 Hours

Section.	Bed Reading. Ft.	Depth Reading. Ft.	Depth, Ft.	Λ	c %	Remarks.
2	0.967	1.017	0.050	9.90	2.000	Near bed.
		1.167	0.200	9.90	2.000	
		1.210	0.243	9.90	2.000	Below density layer.
		1.267	0.300	9.90	2.000	Above density layer.
		1.467	0.500	2.15	0.145	
		1.504	0.537	1.50	0.100	Near top.
3	1.012	1.062	0.050	9.90	1.800	Near bed.
		1.212	0.200	9.90	1.800	
		1.292	0.280	9.90	1.800	
		1.358	0.346	9.90	1.800	
		1.512	0.500	1.75	0.150	
		1.614	0.602	0.10	0.010	Near top.
4	0.891	0.941	0.050	7.70	1.130)	Probe not working satisfactorily
		1.091	0.200	7.70	1.130)	
		1.222	0.331	7.00	0.930)	
		1.301	0.410	2.20	0.215)	
		1.391	0.500	0.20	0.020)	
		1.543	0.652	0.00	0.000)	
5	1.218	1.268	0.050	10.20	2.080	Near bed.
		1.418	0.200	10.20	2.080	
		1.564	0.346	10.20	2.080	
		1.596	0.378	9.10	1.580	
		1.718	0.500	4.70	0.440	
		1.943	0.725	0.10	0.010	Near top.
6	0.947	0.997	0.050	10.10	1.960	Near bed.
		1.147	0.200	10.10	1.960	
		1.317	0.370	10.10	1.960	
		1.377	0.430	10.10	1.960	
		1.447	0.500	8.40	1.310	
		1.711	0.764	0.50	0.050	Near top.

Table: 6 - S - 2

Time since test started: 4 Hours

Section.	Bed Reading, Ft.	Depth Reading. Ft.	Depth. Ft.	Ω	c %	Remarks
2	0.967	1.017	0.050	10.00	2.080	Near bed.
		1.167	0.200	10.00	2.080	
		1.367	0.400	10.00	2.080	
		1.467	0.500	2.00	0.130	
		1.503	0.536	1.50	0.100	Near top.
3	1.012	1.062	0.050	9.90	1.800	Near bed.
		1.212	0.200	9.90	1.800	
		1.412	0.400	9.90	1.800	
		1.512	0.500	3.10	0.280	
		1.605	0.537	0.70	0.060	Near top.
4	0.891	0.941	0.050	8.20	1.300	Near bed.
		1.091	0.200	7.60	1.100	
		1.291	0.400	7.10	0.960	
		1.391	0.500	4.10	0.420	
		1.541	0.650	0.20	0.020	Near top.
5	1.218	1.268	0.050	10.20	2.080	Near bed.
		1.418	0.200	10.20	2.080	
		1.718	0.500	10.20	2.080	
		1.818	0.600	4.30	0.390	
		1.937	0.719	0.20	0.020	Near top.
6	0.947	0.997	0.050	10.10	1.960	Near bed.
		1.147	0.200	10.10	1.960	
		1.447	0.500	10.10	1.960	
		1.597	0.650	4.80	0.500	
		1.710	0.763	0.20	0.020	Near top.

Table: 6 - S - 3

Time since test started: 6 Hours

Section.	Bed Reading, Ft.	Depth Reading, Ft.	Depth, Ft.	Ω	c %	Remarks.
2	0.967	1.017	0.050	10.00	2.080	Near bed.
		1.167	0.200	10.00	2.080	
		1.364	0.400	10.00	2.080	
		1.444	0.477	10.00	2.080	
		1.467	0.500	4.20	0.310	
		1.503	0.536	3.15	0.210	Near top.
3	1.012	1.062	0.050	9.90	1.800	Near bed.
		1.212	0.200	9.90	1.800	
		1.412	0.400	9.90	1.800	
		1.512	0.500	9.90	1.800	
		1.542	0.530	5.60	0.560	
		1.608	0.596	1.35	0.120	Near top.
4	0.891	0.941	0.050	8.20	1.300	Near bed.
		1.091	0.200	8.20	1.300	
		1.291	0.400	7.60	1.100	
		1.391	0.500	7.40	1.040	
		1.471	0.580	1.60	0.155	
		1.542	0.651	0.00	0.000	Near top.
5	1.218	1.268	0.050	10.20	2.080	Near bed.
		1.418	0.200	10.20	2.080	
		1.718	0.500	10.20	2.080	
		1.818	0.600	10.20	2.080	
		1.867	0.649	3.80	0.340	
		1.933	0.715	0.30	0.025	Near top.
6	0.947	0.997	0.050	10.10	1.960	Near bed.
		1.147	0.200	10.10	1.960	
		1.447	0.500	10.10	1.960	
		1.547	0.600	10.10	1.960	
		1.597	0.650	10.10	1.960	
		1.710	0.763	0.50	0.530	Near top.

Table: 6 - S - 4

Time since start of test: 8 Hours

Section.	Bed Reading. Ft.	Depth Reading. Ft.	Depth. Ft.	Ω	c %	Remarks
2	0.967	1.017	0.050	10.00	2.080	Near bed.
		1.167	0.200	10.00	2.080	
		1.450	0.483	10.00	2.080	Below interface
		1.467	0.500	8.70	1.320	Above interface
		1.502	0.535	3.10	0.210	Near top.
3	1.012	1.062	0.050	9.90	1.800	Near bed.
		1.212	0.200	9.90	1.800	
		1.512	0.500	9.90	1.800	
		1.547	0.535	9.90	1.800	Below interface
		1.554	0.542	8.70	1.180	Above interface
		1.597	0.585	1.35	0.120	Near top.
4	0.891	0.941	0.050	8.20	1.300	Near bed.
		1.091	0.200	8.20	1.300	
		1.391	0.500	7.20	0.980	
		1.494	0.603	1.40	0.135	
		1.524	0.633	0.00	0.000	Near top.
5	1.218	1.268	0.050	10.20	2.080	Near bed.
		1.418	0.200	10.20	2.080	
		1.718	0.500	10.20	2.080	Below interface.
		1.880	0.662	5.60	0.550	Above interface.
		1.927	0.709	0.30	0.025	Near top.
6	0.947	0.997	0.050	10.10	1.960	Near bed.
		1.147	0.200	10.10	1.960	
		1.447	0.500	10.10	1.960	
		1.617	0.670	10.00	1.910	
		1.709	0.762	0.50	0.050	Near top.

Table: 6 - S - 5

Time since start of test: 10 Hours

Section	Bed Reading. Ft.	Depth Reading. Ft.	Depth Ft.	Ω	c %	Remarks
2	0.967	1.017	0.050	10.00	2.080	Near bed.
		1.167	0.200	10.00	2.080	
		1.450	0.483	10.00	2.080	
		1.467	0.500	9.95	2.060	
		1.501	0.534	3.50	0.250	Near top.
3	1.012	1.062	0.050	9.90	1.800	Near bed.
		1.212	0.200	9.90	1.800	
		1.512	0.500	9.90	1.800	
		1.552	0.540	9.90	1.800	
		1.570	0.558	5.60	0.560	
		1.604	0.592	1.50	0.130	Near top.
4	0.891	0.941	0.050	8.20	1.300	Near bed.
		1.091	0.200	8.20	1.300	
		1.391	0.500	7.40	1.040	
		1.426	0.535	6.90	0.910	
		1.480	0.589	4.30	0.450	
		1.542	0.651	0.00	0.000	Near top.
5	1.218	1.268	0.050	10.20	2.080	Near bed.
		1.418	0.200	10.20	2.080	
		1.718	0.500	10.20	2.080	
		1.886	0.668	6.10	0.640	
		1.904	0.686	2.20	0.185	
		1.937	0.719	0.40	0.030	Near top.
6	0.947	0.997	0.050	10.10	1.960	Near bed.
		1.147	0.200	10.10	1.960	
		1.447	0.500	10.10	1.960	
		1.597	0.650	10.10	1.960	
		1.667	0.720	6.30	0.750	
		1.709	0.762	0.90	0.085	Near top.

Table: 6 - S - 6

Time since start of test: 24 Hours

Section	Bed Reading. Ft.	Depth Reading. Ft.	Depth Ft.	Λ	c %	Remarks
2	0.969	1.019	0.050	9.9	2.000	Near bed.
		1.169	0.200	9.9	2.000	
		1.469	0.500	9.9	2.000	
		1.489	0.520	9.5	1.780	
		1.496	0.527	7.2	0.750	Near top.
3	CHANNEL NO. 3 WAS NOT WORKING					
4	0.891	0.941	0.050	8.2	1.300	Near bed.
		1.091	0.200	8.2	1.300	
		1.391	0.500	7.4	1.040	
		1.472	0.581	7.2	0.980	
		1.534	0.643	3.3	0.330	Near top.
5	1.219	1.269	0.050	10.2	2.080	Near bed.
		1.419	0.200	10.2	2.080	
		1.719	0.500	10.2	2.080	
		1.910	0.691	9.4	1.710	
		1.931	0.712	5.5	0.540	Near top.
6	0.946	0.996	0.050	10.1	1.960	Near bed.
		1.146	0.200	10.1	1.960	
		1.446	0.500	10.1	1.960	
		1.678	0.732	6.5	0.790	
		1.700	0.754	1.3	0.120	Near top.

TEST RUN 7

General Data

Material Used: Salt

Dye Used: Fluoresene

Flume Slope: 1 in 180

Sluice Gate Opening: 5"

Test Started: 12:30 Noon on 9.9.64

Duration of Test: 25 Hours

Observation Time: 2, 4, 6, 8, 10, and 24 hours after the test started.

Data of Conductivity Probes

Conductivity Probe No.	Attenuator Reading	Range Set	Used at Section	Bed Reading, Ft.
2	x50	0 to 2% salinity concentration by weight	2	0.970
3	x50		3	1.013
1	x100		4	0.891
5	x100		5	1.217
6	x200		6	1.387

Flow Data

Flow over weir = Free

Gauge reading upstream of weir = 0.693 Feet

Reading for no flow = 0.587 Feet

∴ Head over weir = 0.106 Feet

From flow curve for weir running free, by extrapolation,

Discharge Q = 0.0052 C.F.S.

OBSERVATIONS OF DENSITY LAYER FRONT.

Test Run 7

Serial No. of Observation.	Observed Between Sections,	Distance Travelled, Ft.	Time Taken, Secs.	Average Velocity. Ft./Secs.
1	3 and 4	20	266	0.075
2	4 and 5	20	270	0.074
3	5 and 6	10	142	0.070
4	6 and D/S sluice gate	5	70	0.071

Overall average velocity = 0.073 Ft./Sec.

Shape of Front.

Round nosed having its head bigger than general thickness following it and lifted up slightly above the flume bed.

PROFILE MEASUREMENTS.

Test Run: 7

Table: 7 - P - 1

Time since test started: 2 Hours

Section.	Bed Reading. Ft.	Density Layer Reading, Ft.	*Top Reading, Ft.	d Col. 3- Col. 2, Ft.	D Col. 4- Col. 2, Ft.	Λ_1	C_0 %	H Ft.
1	2	3	4	5	6	7	8	9
1	0.072	-	0.682	-	0.610			
2	0.236	0.378	0.936	0.142	0.700	•		
3	0.071	0.319	0.894	0.248	0.823	9.9	2.000	0.106
4	0.104	0.520	1.037	0.416	0.933			
5	0.122	0.632	1.182	0.510	1.060	T = 74°F		
6	0.098	-	1.217	-	1.119			

Where d = Thickness of density layer in feet.

D = Total depth of flow in feet,

Λ_1 = Deflection of recorder for water flowing over weir,

Λ = Deflection of recorder,

C_0 = Concentration percent by weight, taken from -c plot of the probe used.

H = Head over weir in feet.

*Top readings went on decreasing consistently throughout the test because there was a leakage from the pump at the tail end of the flume.

•Probe No. 2 was used. Refer Appendix B for its calibration curve. Salinity of water in the beginning of the test was 2% by weight.

NOTE: These signs will have the same interpretation throughout all profile measurements

Table: 7 - P - 2

Time since test started: 4 Hours

Section.	Bed Read-ing. Ft.	Density Layer Reading. Ft.	*Top Reading, Ft.	d Col. 3- Col. 2, Ft.	D Col. 4- Col. 2, Ft.	Λ_1	C_0 %	H Ft.
1	2	3	4	5	6	7	8	9
1	0.072	-	0.680	-	0.608			
2	0.236	0.630	0.934	0.394	0.698	9.10	1.550	0.106
3	0.071	0.570	0.892	0.499	0.821			
4	0.104	0.777	1.035	0.673	0.931			
5	0.122	0.923	1.180	0.801	1.058	T= 74°F		
6	0.098	-	1.215	-	1.117			

Table: 7 - P - 3

Time since test started: 6 Hours

1	0.072	-	0.680	-	0.608			
2	0.236	0.784	0.934	0.548	0.698	8.35	1.140	0.104
3	0.071	0.735	0.892	0.664	0.821			
4	0.104	0.873	1.035	0.769	0.931			
5	0.122	1.018	1.180	0.896	1.058	T = 74.5°F		
6	0.098	-	1.215	-	1.117			

Table: 7 - P - 4

Time since test started: 8 Hours

1	0.072	-	0.678	-	0.606			
2	0.236	0.787	0.933	0.551	0.697	7.9	0.960	0.104
3	0.071	0.749	0.891	0.678	0.820			
4	0.104	0.897	1.034	0.793	0.930			
5	0.122	1.037	1.179	0.915	1.057	T= 75°F		
6	0.098	-	1.214	-	1.116			

Table: 7 - P - 5

Time since test started: 10 Hours

Section.	Bed Reading, Ft.	Density Layer Reading, Ft.	*Top Reading. Ft.	d Col. 3- Col. 2, Ft.	D Col. 4- Col. 2, Ft.	Λ_1	C_0 %	H Ft.
1	2	3	4	5	6	7	8	9
1	0.072	-	0.676	-	0.604			
2	0.236	0.795	0.932	0.559	0.696	7.9	0.960	0.104
3	0.071	0.761	0.890	0.690	0.819			
4	0.104	0.900	1.033	0.796	0.929			
5	0.122	1.049	1.178	0.927	1.056	T= 75.5°F		
6	0.098	-	1.213	-	1.115			

Table: 7 - P - 6

Time since test started: 24 Hours

Section.	Bed Reading, Ft.	Density Layer Reading, Ft.	*Top Reading. Ft.	d Col. 3- Col. 2, Ft.	D Col. 4- Col. 2, Ft.	Λ_1	C_0 %	H Ft.
1	0.072	-	0.671	-	0.599			
2	0.236	0.801	0.926	0.565	0.690			
3	0.071	0.774	0.884	0.703	0.813			0.100
4	0.104	0.917	1.027	0.813	0.923			
5	0.122	1.062	1.172	0.940	1.050			
6	0.098	-	1.207	-	1.109	/6.0 T = 76°F	0.690	

/Probe No. 6 was used. Refer Appendix B for its calibration curve.

VELOCITY MEASUREMENTS.

Test Run 7

Section of observation: 3

Distance from upstream sluice gate: 45 Feet

Table: 7 - V - 1

Time since test started: 2 Hours

Position From Bed, Ft.	Distance Travelled, Inches	Time Taken. Secs.	Velocity, Inch/Sec.	Remarks,
0.000	-	-	0	Bed,
0.042	1	40.2	0.025	Flow downwards
0.167	2	11.5	0.174	" "
0.333	2	34.3	0.058	" "
0.650	-1.5	17	-0.088	Flow upwards,
0.746	-2	37.8	-0.053	" "
0.823	-	-	0	Near surface,

Table: 7 - V - 2

Time since test started: 4 Hours

Position From Bed, Ft.	Distance Travelled, Inches	Time Taken. Secs.	Velocity, Inch/Sec.	Remarks,
0.000	-	-	0	Bed,
0.042	2	82.8	0.024	Flow downwards
0.167	2	20.2	0.099	" "
0.333	2	31.2	0.064	" "
0.654	-2	22.2	-0.090	Flow upwards,
0.738	-2	35.2	-0.057	" "
0.821	-1	210	-0.005	Near surface.

Table: 7 - V - 3

Time since test started: 6 Hours

Position From Bed, Ft.	Distance Travelled, Inches	Time Taken. Secs.	Velocity, Inch/Sec.	Remarks,
0.000	-	-	0.000	Bed.
0.042	2	10.0	0.200	Flow downwards
0.167	2	20.8	0.096	" "
0.125	3	11.0	0.273	" "
0.529	-2	22.6	-0.089	Flow upwards,
0.654	-2	40.0	-0.050	" "
0.738	-2	61.2	-0.033	" "
0.821	-	-	0.000	Surface.

Table: 7 - V - 4

Time since test started: 8 Hours.

Position From Bed. Ft.	Distance Travelled. Inches	Time Taken. Secs.	Velocity. Inch/Sec.	Remarks.
0.000	-	-	0.000	Bed.
0.042	2	13.4	0.149	Flow downwards
0.125	2	20.4	0.098	" "
0.250	-2	49.2	-0.041	Flow upwards.
0.528	-1	61.4	-0.016	" "
0.695	-1	49.8	-0.020	" "
0.820	-1	51.0	-0.0196	Surface.

Table: 7 - V - 5

Time since test started: 10 Hours.

0.000	-	-	0.000	Bed.
0.042	2	28.8	0.069	Flow downwards
0.167	2	12.4	0.161	" "
0.250	-2	35.2	-0.057	Flow upwards
0.486	-2	54.0	-0.037	" "
0.694	-1	41.7	-0.024	" "
0.819	-	-	0.000	Surface.

Table: 7 - V - 6

Time since test started: 24 Hours.

0.000	-	-	0.000	Bed.
0.167	2	12.2	0.164	Flow downwards
0.333	2	37.2	0.054	" "
0.641	-2	64.0	-0.031	Flow upwards.
0.813	-	-	0.000	Surface.

SALINITY CONCENTRATION MEASUREMENTS

Test Run 7

Table: 7 - S - 1

Time since test started: 2 Hours

Section	Bed Reading, Ft.	Depth Reading, Ft.	Depth, Ft.	Ω	c %	Remarks.
2	0.970	1.020	0.050	9.90	2.000	Near bed.
		1.170	0.200	2.80	0.190	
		1.470	0.500	1.60	0.105	
		1.570	0.600	1.55	0.100	
		1.669	0.699	1.10	0.070	Near top,
3	1.013	1.063	0.050	9.85	1.720	Near bed,
		1.213	0.200	9.85	1.720	
		1.513	0.500	3.20	0.290	
		1.613	0.600	2.65	0.235	
		1.826	0.813	1.75	0.150	Near top.
4	0.891	0.941	0.050	6.60	0.835	Near bed.
		1.091	0.200	6.30	0.770	
		1.391	0.500	0.50	0.050	
		1.491	0.600	0.20	0.020	
		1.818	0.927	0.00	0.000	Near top,
5	1.217	1.267	0.050	10.20	2.080	Near bed,
		1.417	0.200	10.20	2.080	
		1.717	0.500	9.10	1.580	Near interface.
		1.817	0.600	2.30	0.193	
	0.991	2.042	1.051	0.20	0.020	Near top,
6	1.387	1.437	0.050	9.70	1.790	Near bed,
		1.587	0.200	9.00	1.530	
		1.887	0.500	7.90	1.140	
		1.987	0.600	5.70	0.630	
	0.892	2.011	1.119	0.20	0.020	Near top,

Table: 7 - S - 2

Time since test started: 4 Hours

Section.	Bed Reading, Ft.	Depth Reading, Ft.	Depth, Ft.	Λ	c %	Remarks.
2	0.970	1.020	0.050	9.90	2.000	Near bed.
		1.170	0.200	9.90	2.000	
		1.370	0.400	9.80	1.970	
		1.392	0.422	6.80	0.665	Below interface
		1.470	0.500	1.40	0.090	
		1.570	0.600	1.20	0.075	Near top.
		1.663	0.693	1.10	0.070	
3	1.013	1.063	0.050	9.90	1.780	Near bed,
		1.213	0.200	9.90	1.780	
		1.313	0.300	9.85	1.720	
		1.413	0.400	9.50	1.460	
		1.513	0.500	2.55	0.225	
		1.613	0.600	2.00	0.175	
		1.820	0.807	1.80	0.160	Near top.
4	0.891	0.941	0.050	5.50	0.620	
		1.091	0.200	5.50	0.620	
		1.391	0.500	5.00	0.540	
		1.491	0.600	4.50	0.470	
		1.549	0.658	1.20	0.120	Below interface
		1.550	0.659	0.90	0.090	Above interface
		1.816	0.925	0.00	0.000	
5	0.991	1.041	0.050	10.00	2.000	Near bed.
		1.191	0.200	10.00	2.000	
		1.491	0.500	9.90	1.950	
		1.591	0.600	9.90	1.950	
		1.759	0.768	3.80	0.340	Below interface.
		1.768	0.777	2.20	0.185	Above interface
		2.044	1.053	0.20	0.020	Near top.
6	0.892	0.942	0.050	8.60	1.380	Near bed,
		1.092	0.200	8.00	1.180	
		1.392	0.500	7.60	1.050	
		1.492	0.600	7.50	1.020	
		1.652	0.760	5.50	0.600	
		1.692	0.800	3.70	0.370	
		2.009	1.117	0.10	0.010	Near top.

Table: 7 - S - 3

Time since test started: 6 Hours

Section.	Bed Reading. Ft.	Depth Reading. Ft.	Depth. Ft.	Λ	c %	Remarks.
2	0.970	1.020	0.050	9.95	2.040	Near bed.
		1.170	0.200	9.95	2.040	
		1.470	0.500	9.80	1.970	
		1.498	0.528	8.60	1.270	Below interface
		1.538	0.568	3.30	0.230	Above interface
		1.664	0.694	1.35	0.085	Near top.
3	1.013	1.063	0.050	9.90	1.780	Near bed.
		1.213	0.200	9.90	1.780	
		1.513	0.500	9.90	1.780	
		1.676	0.663	9.30	1.360	Below interface
		1.698	0.685	4.40	0.410	Above interface
		1.823	0.310	2.05	0.180	Near top,
4	0.890	0.940	0.050	6.50	0.810	Near bed.
		1.090	0.200	6.20	0.750	
		1.390	0.500	5.70	0.570	
		1.653	0.763	3.50	0.350	Below interface
		1.679	1.789	0.90	0.090	Above interface
		1.815	0.925	0.10	0.010	Near top.
5	0.991	1.041	0.050	10.20	2.080	Near bed.
		1.191	0.200	10.20	2.080	
		1.491	0.500	10.20	2.080	
		1.874	0.883	7.70	1.030	Below interface
		1.898	0.907	3.10	0.170	Above interface
		2.040	1.049	0.30	0.025	Near top.
6	0.893	0.943	0.050	8.50	1.350	Near bed.
		1.093	0.200	8.50	1.350	
		1.393	0.500	8.00	1.180	
		1.750	0.857	7.50	1.020	
		1.803	0.910	7.10	0.920	
		2.010	1.117	0.15	0.013	Near top.

Table: 7 - S - 4

Time since test started: 8 Hours

Section.	Bed Reading. Ft.	Depth Reading. Ft.	Depth. Ft.	Ω	c %	Remarks.
2	0.970	1.020	0.050	9.95	2.040	Near bed.
		1.470	0.500	9.95	2.040	
		1.491	0.521	9.95	2.040	Below interface
		1.531	0.561	5.90	0.500	Above interface
		1.659	0.689	1.55	0.100	Near top.
3	1.013	1.063	0.050	9.90	1.780	Near bed,
		1.513	0.500	9.90	1.780	
		1.661	0.648	9.90	1.780	Below interface
		1.700	0.687	6.00	0.600	Above interface
		1.820	0.807	2.20	0.190	Near top,
4	0.890		0.050	6.70	0.860	Near bed,
			0.500	5.60	0.640	
		1.667	0.777	3.20	0.320	Below interface
		1.696	0.806	0.70	0.070	Above interface
		1.815	0.925	0.10	0.010	Near top,
5	0.991	1.041	0.050	10.20	2.080	Near bed
		1.491	0.500	10.10	2.050	
		1.892	0.901	6.70	0.760	Below interface
		1.917	0.926	2.40	0.205	Above interface
		2.038	1.047	0.20	0.020	Near top,
6	0.893	0.943	0.050	8.50	1.350	Near bed.
		1.393	0.500	7.30	0.970	
		1.793	0.900	6.60	0.810	
		1.823	0.930	6.30	0.750	
		2.009	1.116	0.10	0.010	Near top.

Table: 7 - S - 5

Time since test started: 10 Hours ,

Section .	Bed Reading , Ft.	Depth Reading . Ft.	Depth , Ft.	Ω	c %	Remarks .
2	0.970	1.020	0.050	9.95	2.040	Near bed .
		1.470	0.500	9.90	2.000	
		1.492	0.522	9.90	2.000	Below interface
		1.540	0.570	4.60	0.345	Above interface
		1.662	0.692	1.20	0.075	Near top .
3	1.013	1.063	0.050	9.90	1.780	Near bed .
		1.513	0.500	9.90	1.780	
		1.707	0.694	7.10	0.830	Below interface
		1.732	0.719	3.60	0.325	Above interface
		1.820	0.807	2.40	0.210	Near top .
4	0.891	0.941	0.050	6.70	0.860	Near bed .
		1.391	0.500	5.80	0.675	
		1.671	0.780	3.40	0.340	Below interface
		1.703	0.812	0.90	0.090	Above interface
		1.814	0.923	0.20	0.020	Near top .
5	0.991	1.041	0.050	10.20	2.080	Near bed .
		1.491	0.500	10.20	2.080	
		1.915	0.924	4.50	0.410	Below interface
		1.931	0.940	2.00	0.170	Above interface
		2.040	1.049	0.40	0.030	Near top .
6	0.893	0.943	0.050	8.50	1.340	Near bed .
		1.393	0.500	8.10	1.210	
		1.813	0.920	6.40	0.765	
		1.843	0.950	6.00	0.690	
		2.008	1.115	0.25	0.022	Near top .

Table: 7 - S - 6

Time since test started: 24 Hours

Section	Bed Reading . Ft.	Depth Reading . Ft.	Depth . Ft.	Λ	c %	Remarks
2	0.966	1.016	0.050	10.00	2.080	Near bed.
		1.466	0.500	10.00	2.080	
		1.521	0.555	10.00	2.080	Below interface
		1.556	0.590	5.80	0.480	Above interface
		1.654	0.688	2.55	0.175	Near top.
3	1.014	1.064	0.050	9.90	1.780	Near bed.
		1.514	0.500	9.90	1.780	
		1.704	0.690	9.90	1.780	Below interface
		1.733	0.719	6.00	0.620	Above interface
		1.815	0.801	2.60	0.230	Near top.
4	0.890	0.940	0.050	9.00	1.590	Near bed,
		1.390	0.500	8.50	1.400	
		1.693	0.803	3.70	0.372	Below interface
		1.720	0.830	1.40	0.133	Above interface
		1.810	0.920	0.20	0.020	Near top,
5	0.988	1.038	0.050	10.20	2.080	Near bed.
		1.488	0.500	10.20	2.080	
		1.912	0.924	8.00	1.130	Below interface
		1.942	0.954	3.40	0.300	Above interface
		2.032	1.044	0.80	0.065	Near top,
6	0.893	0.943	0.050	10.10	1.960	Near bed.
		1.393	0.500	10.10	1.960	
		1.893	1.000	6.80	0.850	
		1.945	1.052	1.45	0.135	
		2.002	1.109	0.40	0.035	Near top.

Test Run 8

General Data

Material Used: Aluminium silicate.

Flume Slope: 1 in 180.

Sluice Gate Opening: 5".

Test Started: 12:30 on 12.9.64.

Duration of Test: 25 Hours.

Observation Time: 2, 4, 6, 8, 10, and 24 hours after the start of the test.

Data of Syphons

Syphon No.	Used at Section	Bed Reading Ft.	Bed Reading Corrected for Syphon Diameter
1	2	1.355	1.345
2	3	1.160	1.150
3	4	1.178	1.168
4	5	1.018	1.008
5	6	0.898	0.888

Flow Data

Flow over weir = Free.

Gauge reading upstream of weir = 0.747.

Reading for no flow = 0.587.

∴Head over weir = 0.160.

From free flowing weir curve in Appendix A

$$Q = 0.0148 \text{ C.F.S.}$$

OBSERVATIONS OF DENSITY LAYER FRONT

Test Run: 8

Serial No.	Observed Between Sections	Distance Travelled Ft.	Time Taken Secs.	Average Velocity Ft./Sec.
1	2 and 3	20	175	0.114
2	3 and 4	20	179	0.112
3	4 and 5	20	173	0.116
4	5 and 6	10	84	0.119
5	6 and D/S sluice gate	5	40	0.125

Overall average velocity = 0.115 Ft./Sec.

Shape of Front

Round nosed having its head bigger than general thickness following it and lifted up about 1/4 inch above the flume bed.

PROFILE MEASUREMENTS

Test Run 8

Table: 8 - P - 1

Time since test started: 2 Hours

Section	Bed Reading Ft.	Density Layer Reading Ft.	Reading of Interlayer Ft.	*Top Reading Ft.	d Col. 3- Col. 2 Ft.	d_1 Col. 4- Col. 3 Ft.	D Col. 5- Col. 2 Ft.	S_o	T °F.	H Ft.
1	2	3	4	5	6	7	8	9	10	11
1	0.072	-	-	0.708	-	-	0.636			
2	0.236	0.481	0.952	0.964	0.245	0.471	0.728	1.007		
3	0.071	0.480	0.910	0.922	0.409	0.430	0.851		62	
4	0.104	0.640	1.003	1.065	0.536	0.363	0.961			0.160
5	0.122	0.794	1.123	1.211	0.672	0.329	1.089			
6	0.098	-	-	1.245	-		1.147			

Where d = Thickness of density layer in feet.
d_1 = Thickness of interlayer in feet.
D = Total depth of flow in feet.
S_o = Specific gravity of water flowing over weir.
S = Specific gravity of water drawn from any depth at test sections.
T = Temperature of water flowing over weir in °F.
H = Head over weir in feet.

*Top readings went on decreasing consistently throughout the test because there was a leakage from the pump at the tail end of the flume.

NOTE: These symbols will have the same interpretation throughout all profile measurements.

Table: 8 - P - 2

Time since test started: 4 Hours.

Section	Bed Reading Ft.	Density Layer Reading Ft.	Reading of Interlayer Ft.	*Top Reading Ft.	d Col. 3-Col. 2 Ft.	d_1 Col. 4-Col. 3 Ft.	D Col. 5-Col. 2 Ft.	S_o	T °F.	H Ft.
1	2	3	4	5	6	7	8	9	10	11
1	0.072	-	-	0.707	-	-	0.635			
2	0.236	0.704	0.950	0.962	0.468	0.246	0.725	1.0055		
3	0.071	0.579	0.879	0.921	0.508	0.300	0.850		63	0.159
4	0.104	0.655	1.009	1.063	0.551	0.354	0.959			
5	0.122	0.951	1.126	1.209	0.829	0.175	1.087			
6	0.098	-	-	1.244	-	-	1.146			

Table: 8 - P - 3

Time since test started: 6 Hours.

Section	Bed Reading Ft.	Density Layer Reading Ft.	Reading of Interlayer Ft.	*Top Reading Ft.	d Col. 3-Col. 2 Ft.	d_1 Col. 4-Col. 3 Ft.	D Col. 5-Col. 2 Ft.	S_o	T °F.	H Ft.
1	0.072	-	-	0.706	-	-	0.634			
2	0.236	0.769	0.961	0.961	0.533	0.192	0.725	1.0049		
3	0.071	0.730	0.874	0.920	0.659	0.144	0.849		64	0.158
4	0.104	0.874	1.016	1.062	0.770	0.142	0.958			
5	0.122	1.021	1.162	1.208	0.899	0.141	1.086			
6	0.098	-	-	1.243	-	-	1.145			

Table: 8 - P - 4

Time since test started: 8 Hours.

Section	Bed Read-ing Ft.	Density Layer Reading Ft.	Reading of Interlayer Ft.	*Top Reading Ft.	d Col. 3- Col. 2 Ft.	d_1 Col. 4- Col. 3 Ft.	D Col. 5- Col. 2 Ft.	S_o	T °F.	H Ft.
1	2	3	4	5	6	7	8	9	10	11
1	0.072	-	≠ -	0.705	-	-	0.633			
2	0.236	0.785	0.960	0.960	0.549	0.175	0.724	1.0048		
3	0.071	0.748	0.919	0.919	0.677	0.171	0.848		65	0.155
4	0.104	0.899	1.061	1.061	0.795	0.162	0.957			
5	0.122	1.046	1.207	1.207	0.924	0.161	1.085			
6	0.098	-	1.242	1.242	-	-	1.144			

Table: 8 - P - 5

Time since test started: 10 Hours

1	0.072	-	≠ -	0.704	-	-	0.632			
2	0.236	0.795	0.959	0.959	0.559	0.164	0.723			
3	0.071	0.756	0.918	0.918	0.685	0.162	0.847	1.0043		
4	0.104	0.899	1.060	1.060	0.795	0.161	0.956		66	0.155
5	0.122	1.046	1.206	1.206	0.924	0.160	1.084			
6	0.098	-	-	1.241	-	-	1.143			

≠Interlayer had reached the top surface.

Table: 8 - P - 6

Time since test started: 24 Hours

Section	Bed Read-ing Ft.	Density Layer Reading Ft.	Reading of Interlayer Ft.	*Top Reading Ft.	d Col. 3- Col. 2 Ft.	d_1 Col. 4- Col. 3 Ft.	D Col. 5- Col. 2 Ft.	S_o	T ^oF.	H Ft.
1	2	3	4	5	6	7	8	9	10	11
1	0.072	-	-	0.697	-	-	0.625			
2	0.236	0.804	0.952	0.952	0.568	0.148	0.716			
3	0.071	0.765	0.911	0.911	0.694	0.146	0.840	1.0038	68	0.148
4	0.104	0.908	1.053	1.053	0.804	0.145	0.949			
5	0.122	1.055	1.199	1.199	0.933	0.144	1.077			
6	0.098	-	-	1.234	-	-	1.136			

Table: 8 - P - 7

Reading of Deposits at Bed of Flume.

Section	Bed Read-ing Ft.	Reading of Deposits Ft.	Thickness of Deposits Ft.	Remarks
1	0.072	0.076	0.004	These readings were taken 24 hours after the test was stopped and the flume drained out.
2	0.236	0.241	0.005	
3	0.071	0.076	0.005	
4	0.104	0.109	0.005	
5	0.122	0.126	0.004	
6	0.098	0.102	0.004	

MEASUREMENTS OF DEPOSITS AT FLUME BED.

Test Run 8

Plate No.	Laid at Section	Weight of Plate Grams	Total Weight Grams	Weight of Deposits Grams	Area of Plate Inches^2	Time for Deposits $T+t_d$ Hours	Deposits per Inch^2 Grams	Net Deposits/ Inch^2 in T Hours Grams
1	2	4.27	5.98	1.71	4.50	$24+t_d$	0.380	0.156
2	2	4.23	5.24	1.01	4.50	t_d	0.224	-
5	4	4.32	6.10	1.78	4.50	$24+t_d$	0.395	0.171
6	4	4.30	5.30	1.00	4.47	t_d	0.224	-
9	6	4.30	6.30	2.00	4.50	$24+t_d$	0.444	0.188
10	6	4.28	5.43	1.15	4.50	t_d	0.256	-

Where T = Time in hours for which material was depositing on the plate.

t_d = Time in hours for which flume was being drained out, starting from the stopping of the test.

Leakage Through Pump

Test Run 8

Checking time = 12 hours.

Weight of leakage (Aluminum silicate mixture with water) = 21.5 lbs.

Specific gravity of mixture = 1.004

$\therefore$ Volume of leakage = $\frac{21.5}{1.004 \times 62.4}$ = 0.343 cu. ft.

Hourly leakage = $\frac{0.343}{12}$ = 0.0286 cu. ft.

Test Run 8

Calculation for Maximum Velocities in the Lower Layer

Assumption: That velocity distribution is parabolic.

1. Time since test started = 2 Hours.

Gauge reading upstream of weir = 0.747 Feet.

Reading for no flow = 0.587 Feet.

∴ Head over weir = 0.160 Feet.

From flow curve of weir running free (Appendix A)

$Q = 0.0148$ C.F.S.

$$\therefore 0.0148 = \frac{3}{12}\left[0.559 \times 2/3\, V_m - 0.292 \times 2/3 \times 0.100\right]$$

$\therefore V_m = 0.210$ inch/sec.

2. Time since test started = 4 Hours.

Gauge reading upstream of weir = 0.746 Feet.

Reading for no flow = 0.587 Feet.

∴ Head over weir = 0.159 Feet.

From flow curve of weir running free (Appendix A)

Discharge $Q = 0.0146$ C.F.S.

$$\therefore 0.0146 = \frac{3}{12}\left[0.642 \times 2/3\, V_m - 0.208 \times 2/3 \times 0.048\right]$$

$$= \frac{3}{12} \times \frac{2}{3}\left[0.642\, V_m - 0.01\right]$$

$\therefore V_m = 0.152$ inch/sec.

3. Time since test started = 6 Hours.

Gauge reading upstream of weir = 0.745 Feet.

Reading for no flow = 0.587 Feet.

$\therefore$ Head over weir = 0.158 Feet.

From flow curve of weir running free (Appendix A)

Discharge Q = 0.0145 C.F.S.

$$\therefore 0.0145 = 3 \times 2/3 \times 1/12 \left[0.661 \times V_m - 0.188 \times 0.025 \right]$$

$\therefore V_m = 0.139$ inch/sec.

4. Time since test started = 8 Hours.

Gauge reading upstream of weir = 0.742 Feet.

Reading for no flow = 0.587 Feet.

$\therefore$ Head over weir = 0.155 Feet.

From flow curve of weir running free (Appendix A)

Discharge Q = 0.0136 C.F.S.

$$\therefore 0.0136 = 1/6 \left[0.661 \times V_m - 0.167 \times 0.06 \right]$$

$\therefore V_m = 0.139$ inch/sec.

5. Time since test started = 10 Hours.

Gauge reading upstream of weir = 0.742 Feet.

Reading for no flow = 0.587 Feet.

$\therefore$ Head over weir = 0.155 Feet.

As in the last case,

Discharge Q = 0.0136 C.F.S.

$$\therefore 0.0136 = 1/6 \left[0.706 \times V_m - 0.141 \times 0.025 \right]$$

$\therefore V_m = 0.121$ inch/sec.

6. Time since test started = 24 Hours.

Gauge reading upstream of weir = 0.635 Feet.

Reading for no flow = 0.587 Feet.

∴ Head over weir = 0.048 Feet.

From flow curve of weir running free when extrapolated, gives

$$\text{Discharge } Q = 0.0007 \text{ C.F.S.}$$

$$\therefore 0.0007 = 1/6 \left[0.700 \times V_m - 0.140 \times 0.02 \right]$$

$$\therefore V_m = 0.01 \text{ inch/sec.}$$

VELOCITY MEASUREMENTS

Test Run 8

Section of Observation: 3

Distance from upstream sluice gate: 45 Feet.

Table: 8 - V - 1

Time since test started: 2 Hours.

Position From Bed Ft.	Distance Travelled Inches	Time Taken Secs.	Velocity Inch/Sec.	Remarks
0.851	-2	33.2	-0.060	Surface.
0.809	-2	21.6	-0.093	
0.643	-2	22.2	-0.090	
0.559	-	-	0.000	
0.280	Refer velocity calculations for lower layer.		0.210	Maximum velocity of lower layer.
0.000	-	-	0.000	Bed.

Table: 8 - V - 2

Time since test started: 4 Hours

Position From Bed Ft.	Distance Travelled Inches	Time Taken Secs.	Velocity Inch/Sec.	Remarks
0.850	-1	41.0	-0.024	Surface.
0.808	-1	27.8	-0.036	
0.725	-1	21.4	-0.047	
0.642	-	-	0.000	
0.341	Refer velocity calculations for lower layer.		0.220	Maximum velocity of lower layer.
0.000	-	-	0.000	Bed.

Table: 8 - V - 3

Time since test started: 6 Hours.

Position From Bed Ft.	Distance Travelled Inches	Time Taken Secs.	Velocity Inch/Sec.	Remarks
0.849	-1	116.0	-0.009	Surface.
0.807	-1	58.5	-0.017	
0.682	-1	75.0	-0.013	
0.661	-	-	0.000	
0.329	Refer velocity calculations for lower layer			Maximum velocity of lower layer.
0.000	-	-	0.000	Bed.

Table: 8 - V - 4

Time since test started: 8 Hours.

Position From Bed Ft.	Distance Travelled Inches	Time Taken Secs.	Velocity Inch/Sec.	Remarks
0.848	-2	50.0	-0.040	Surface.
0.723	-2	37.6	-0.053	
0.681	-	-	0.000	
0.330	Refer velocity calculations for lower layer.		0.139	Maximum velocity of lower layer.
0.000	-	-	0.000	Bed.

Table: 8 - V - 5

Time since test started: 10 Hours.

Position From Bed Ft.	Distance Travelled Inches	Time Taken Secs.	Velocity Inch/Sec.	Remarks
0.847	-1.5	94.5	-0.016	Surface.
0.764	-1.5	81.0	-0.018	
0.706	-	-	0.000	
0.343	Refer velocity calculations for lower layer.		0.121	Maximum velocity of lower layer.
0.000	-	-	0.000	Bed.

Table: 8 - V - 6

Time since test started: 24 Hours.

Position From Bed Ft.	Distance Travelled Inches	Time Taken Secs.	Velocity Inch/Sec.	Remarks
0.840	-2.0	133.0	-0.015	Surface.
0.798	-2.0	119.2	-0.017	
0.715	-2.5	120.0	-0.021	
0.350	Refer velocity calculations for lower layer.		0.010	Maximum velocity of lower layer.
0.000	-	-	0.000	Bed.

MEASUREMENTS FOR ALUMINIUM SILICATE CONCENTRATIONS

Test Run 8

Table: 8 - AS - 1

Time since test started: 2 Hours

Section	Bed Reading Ft.	Depth Reading Ft.	Depth Ft.	Specific Gravity S	Remarks
2	1.345	1.405	0.060	1.0051	Near bed.
		1.555	0.210	1.0038	
		1.855	0.510	1.0014	
		2.063	0.718	1.0000	Near top.
3	1.150	1.210	0.060	1.0053	Near bed.
		1.360	0.210	1.0040	
		1.660	0.510	1.0013	
		1.987	0.837	1.0000	Near top.
4	1.168	1.228	0.060	1.0055	Near bed.
		1.378	0.210	1.0043	
		1.678	0.510	1.0038	
		2.115	0.947	1.0000	Near top.
5	1.008	1.068	0.060	1.0055	Near bed.
		1.218	0.210	1.0048	
		1.518	0.510	1.0040	
		2.085	1.077	1.0000	Near top.
6	0.888	0.948	0.060	1.0050	Near bed.
		1.098	0.210	1.0048	
		1.398	0.510	1.0040	
		2.041	1.153	1.0000	Near top.

Table: 8 - AS - 2

Time since test started: 4 Hours

Section	Bed Reading Ft.	Depth Reading Ft.	Depth Ft.	Specific Gravity S	Remarks
2	1.345	1.405	0.060	1.0043	Near bed.
		1.555	0.210	1.0040	
		1.855	0.510	1.0012	
		2.063	0.718	1.0002	Near top.
3	1.150	1.210	0.060	1.0043	Near bed.
		1.360	0.210	1.0041	
		1.660	0.510	1.0032	
		1.987	0.837	1.0002	Near top.
4	1.168	1.228	0.060	1.0044	Near bed.
		1.378	0.210	1.0041	
		1.678	0.510	1.0036	
		2.115	0.947	1.0002	Near top.
5	1.008	1.068	0.060	1.0044	Near bed.
		1.218	0.210	1.0042	
		1.518	0.510	1.0041	
		2.085	1.077	1.0002	Near top.
6	0.888	0.948	0.060	1.0043	Near bed.
		1.098	0.210	1.0042	
		1.398	0.510	1.0039	
		2.041	1.153	1.0002	Near top.

Table: 8 - AS - 3

Time since test started: 6 Hours

Section	Bed Reading Ft.	Depth Reading Ft.	Depth Ft.	Specific Gravity S	Remarks
2	1.345	1.405	0.060	1.0043	Near bed.
		1.555	0.210	1.0040	
		1.855	0.510	1.0024	
		2.063	0.718	1.0002	Near top.
3	1.150	1.210	0.060	1.0043	Near bed.
		1.360	0.210	1.0041	
		1.660	0.510	1.0040	
		1.987	0.837	1.0002	Near top.
4	1.168	1.228	0.060	1.0044	Near bed.
		1.378	0.210	1.0044	
		1.678	0.510	1.0038	
		2.115	0.947	1.0002	Near top.
5	1.008	1.068	0.060	1.0043	Near bed.
		1.218	0.210	1.0043	
		1.518	0.510	1.0039	
		2.085	1.077	1.0002	Near top.
6	0.888	0.948	0.060	1.0043	Near bed.
		1.098	0.210	1.0043	
		1.398	0.510	1.0040	
		2.041	1.153	1.0002	Near top.

Table: 8 - AS - 4

Time since test started: 8 Hours

Section	Bed Read-ing Ft.	Depth Reading Ft.	Depth Ft.	Specific Gravity S	Remarks
2	1.345	1.405	0.060	1.0043	Near bed.
		1.555	0.210	1.0039	
		1.855	0.510	1.0028	
		2.063	0.718	1.0004	Near top.
3	1.150	1.210	0.060	1.0043	Near bed.
		1.360	0.210	1.0042	
		1.660	0.510	1.0035	
		1.987	0.837	1.0004	Near top.
4	1.168	1.228	0.060	1.0043	Near bed.
		1.378	0.210	1.0042	
		1.678	0.510	1.0040	
		2.115	0.947	1.0004	Near top.
5	1.008	1.068	0.060	1.0043	Near bed.
		1.218	0.210	1.0043	
		1.518	0.510	1.0039	
		2.085	1.077	1.0004	Near top.
6	0.888	0.948	0.060	1.0043	Near bed.
		1.098	0.210	1.0042	
		1.398	0.510	1.0040	
		2.041	1.153	1.0004	Near top.

Table: 8 - AS - 5

Time since test started: 10 Hours

Section	Bed Reading Ft.	Depth Reading Ft.	Depth Ft.	Specific Gravity S	Remarks
2	1.345	1.405	0.060	1.0043	Near bed.
		1.555	0.210	1.0040	
		1.855	0.510	1.0036	
		2.057	0.712	1.0005	Near top.
3	1.150	1.210	0.060	1.0042	Near bed.
		1.360	0.210	1.0040	
		1.660	0.510	1.0035	
		1.981	0.831	1.0005	Near top.
4	1.168	1.228	0.060	1.0042	Near bed.
		1.378	0.210	1.0041	
		1.678	0.510	1.0036	
		2.109	0.941	1.0005	Near top.
5	1.008	1.068	0.060	1.0042	Near bed.
		1.218	0.210	1.0041	
		1.518	0.510	1.0038	
		2.079	1.071	1.0005	Near top.
6	0.888	0.948	0.060	1.0042	Near bed.
		1.098	0.210	1.0041	
		1.398	0.510	1.0039	
		2.035	1.147	1.0005	Near top.

Table: 8 - AS - 6

Time since test started: 24 Hours

Section	Bed Reading Ft.	Depth Reading Ft.	Depth Ft.	Specific Gravity S	Remarks
2	1.345	1.405	0.060	1.0040	Near Bed.
		1.555	0.210	1.0035	
		1.855	0.510	1.0026	
		2.055	0.710	1.0008	Near top.
3	1.150	1.210	0.060	1.0039	Near bed.
		1.360	0.210	1.0039	
		1.660	0.510	1.0039	
		1.979	0.829	1.0008	Near top.
4	1.168	1.228	0.060	1.0038	Near bed.
		1.378	0.210	1.0037	
		1.678	0.510	1.0035	
		2.107	0.939	1.0008	Near top.
5	1.008	1.068	0.060	1.0042	Near bed.
		1.218	0.210	1.0042	
		1.518	0.510	1.0035	
		2.077	1.069	1.0008	Near top.
6	0.888	0.948	0.060	1.0037	Near bed.
		1.098	0.210	1.0037	
		1.398	0.510	1.0035	
		2.033	1.145	1.0008	Near top.

APPENDIX F

F-1 Calculations of Parameters

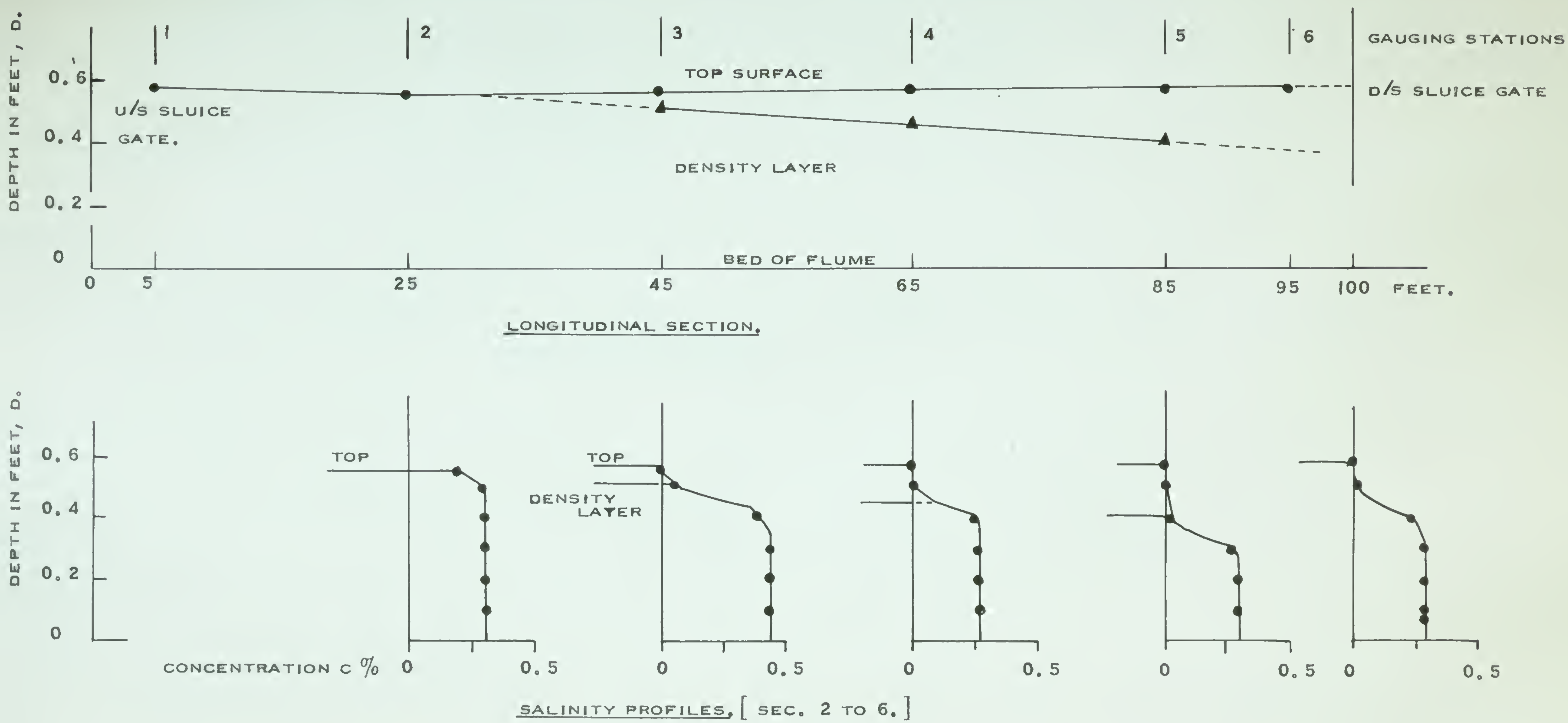
Test Run No.	Set No.	R_b	$-\lambda$	$\sqrt{\lambda_o}$	d/D	$\frac{\mu_b(\rho+\Delta\rho)}{\mu\rho}$	F_b
I	4*	1680	0.0598	0.138	0.698	1.320	0.279
	5	1445	0.0995	0.172	0.723	1.221	0.230
	6	1780	0.0703	0.142	0.742	1.223	0.294
	7	1512	0.0674	0.134	0.766	1.123	0.305
	8	1720	0.0940	0.155	0.780	1.221	0.256
	9/	1243	0.0341	0.091	0.793	1.235	0.181
II	1	1305	0.0213	0.096	0.498	1.560	0.269
	2	2015	0.0112	0.068	0.548	1.380	0.390
	3	1976	0.0199	0.088	0.587	1.321	0.360
	4	1960	0.0236	0.094	0.610	1.204	0.339
	5	2130	0.0190	0.079	0.682	1.204	0.309
	6	1720	0.0331	0.104	0.683	1.247	0.240
	7	1190	0.0419	0.117	0.684	1.257	0.184
	8	1874	0.0335	0.105	0.688	1.266	0.269
	9	1894	0.0245	0.088	0.700	1.146	0.295
	10	1610	0.0406	0.113	0.705	1.030	0.262
	11	1880	0.0327	0.095	0.741	1.035	0.290
III	1	1268	0.0154	0.072	0.495	1.059	0.382
	2	1180	0.0216	0.090	0.612	1.059	0.355
	3	1000	0.0591	0.145	0.644	1.047	0.227
	4	903	0.0569	0.143	0.638	1.016	0.227
	5	1231	0.0188	0.083	0.631	1.028	0.392
	6	1280	0.0591	0.136	0.707	1.011	0.275
	7	646	0.0372	0.109	0.698	1.010	0.260
	8	479	0.0473	0.132	0.630	1.006	0.248
	9	463	0.0446	0.131	0.607	1.016	0.254
	10	457	0.0471	0.135	0.598	1.010	0.265
	11	244	0.0716	0.169	0.572	1.010	0.164

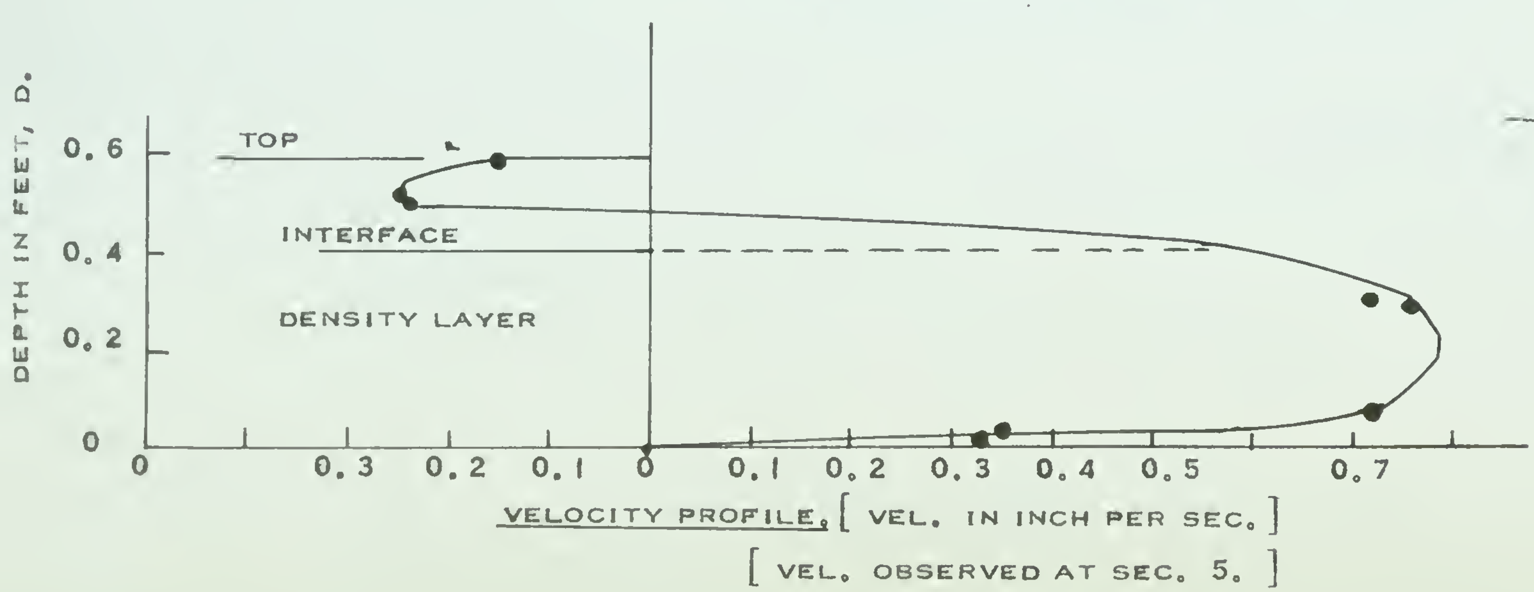
* For the first three sets, velocity measurements could not be made. Effort was being made to work with the current meter, but that did not pick up the low velocities.

/ Calculations for set number 10 were not made, since only one point was observed on the interface.

Test Run No.	Set No.	R_b	$-\lambda$	$\sqrt{\lambda_o}$	d/D	$\frac{\mu_b(\rho+\Delta\rho)}{\mu\rho}$	F_b
IV	1	2300	0.0108	0.067	0.538	1.172	0.354
	2	2370	0.0117	0.068	0.572	1.168	0.350
	3	2015	0.0136	0.073	0.583	1.168	0.298
	4	1762	0.0222	0.093	0.591	1.135	0.290
	5	2250	0.0121	0.069	0.588	1.122	0.386
	6	2175	0.0165	0.079	0.612	1.136	0.342
	7	2320	0.0224	0.091	0.621	1.072	0.395
	8	2250	0.0127	0.065	0.687	1.105	0.354
	9	2205	0.0116	0.062	0.680	1.108	0.350
	10	2120	0.0143	0.066	0.714	1.109	0.321
	11	2040	0.0078	0.048	0.728	1.092	0.321
	12	1880	0.1048	0.156	0.807	1.086	0.253
V	1	1150	0.0076	0.056	0.537	1.130	0.163
	2	1020	0.0395	0.102	0.767	1.140	0.076
	3	850	0.2365	0.231	0.812	1.147	0.064
	4	850	0.3309	0.270	0.819	1.152	0.067
	5	752	0.3704	0.270	0.843	1.179	0.054
	6	863	0.1444	0.167	0.846	1.160	0.064
	7	863	0.2314	0.200	0.866	1.103	0.067
	8	900	0.2344	0.184	0.881	1.121	0.067
	9	871	0.3232	0.212	0.897	1.106	0.059
	10	990	0.3540	0.218	0.900	1.013	0.064
	11	892	0.2270	0.181	0.892	1.082	0.072
	12	763	0.2045	0.175	0.888	1.073	0.067
VI	1	196	0.3719	0.399	0.519	1.093	0.0368
	2	255	0.5332	0.345	0.815	1.546	0.0197
	3	233	0.5193	0.305	0.860	1.185	0.0174
	4	238	0.6383	0.285	0.907	1.282	0.0158
	5	196	0.7323	0.290	0.917	1.316	0.0124
VII	1	207	0.1013	0.227	0.340	1.083	0.0364
	2	213	0.7897	0.532	0.643	1.402	0.0137
	3	522	0.9004	0.455	0.809	1.192	0.0235
	4	169	0.9088	0.437	0.828	1.162	0.0074
	5	333	0.9267	0.440	0.831	1.176	0.0146
	6	433	0.9086	0.396	0.865	1.100	0.0181
VIII	1	512	0.2210	0.315	0.481	1.063	0.0777
	2	414	0.2723	0.324	0.598	1.056	0.0478
	3	415	0.3695	0.309	0.777	1.054	0.0325
	4	419	0.6353	0.390	0.798	1.073	0.0322
	5*	412	0.8062	0.379	0.862	1.061	0.0293

* Calculations for set no. 6 were not made as the drain pipe of the pump, installed at the tail end of the flume, had broken and there was considerable leakage through it.

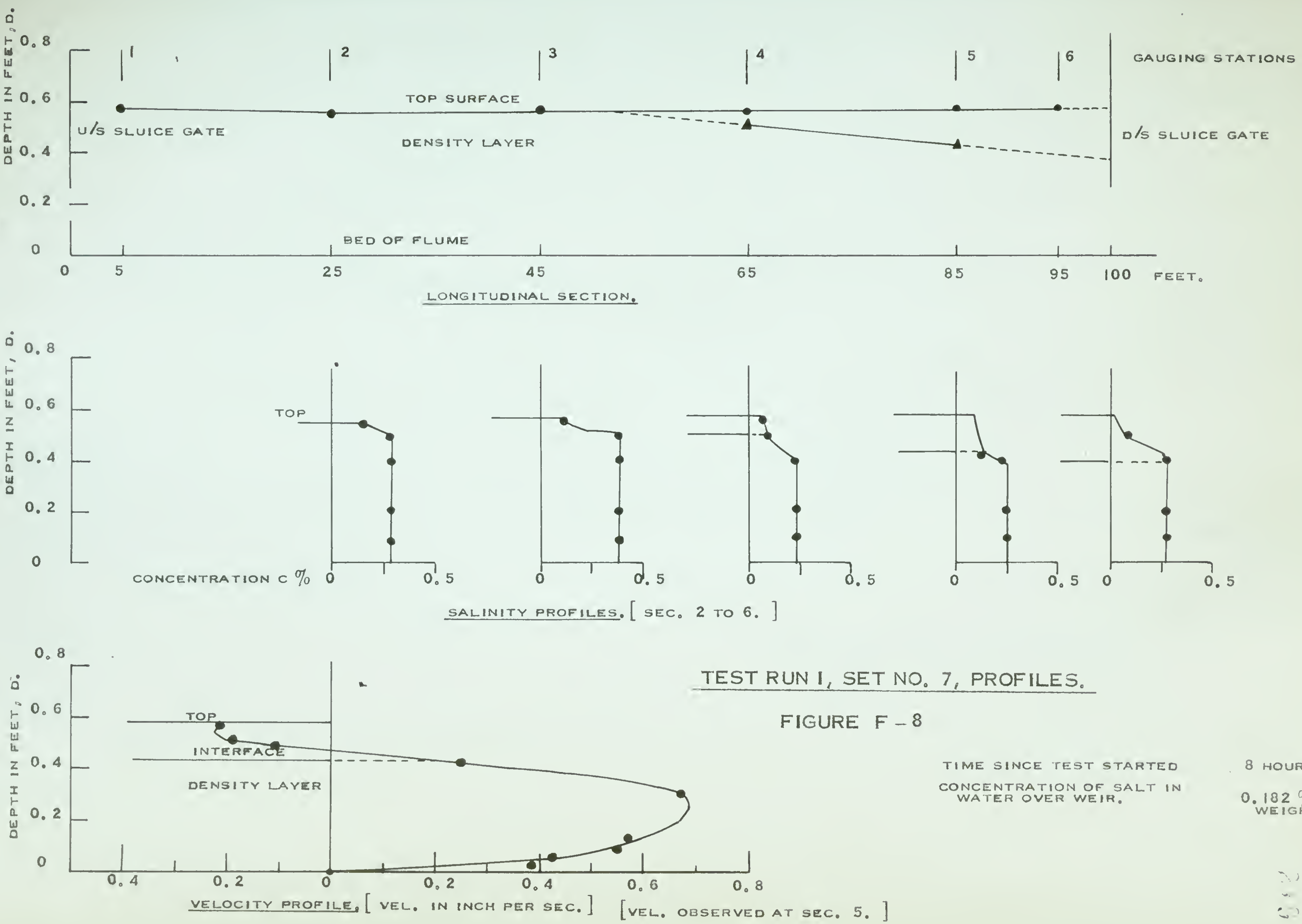




TEST RUN I, SET NO. 4, PROFILES.

FIGURE F – 7

TIME SINCE TEST STARTED	4 HOURS
CONCENTRATION OF SALT IN WATER OVER WEIR.	0.185 % BY WEIGHT

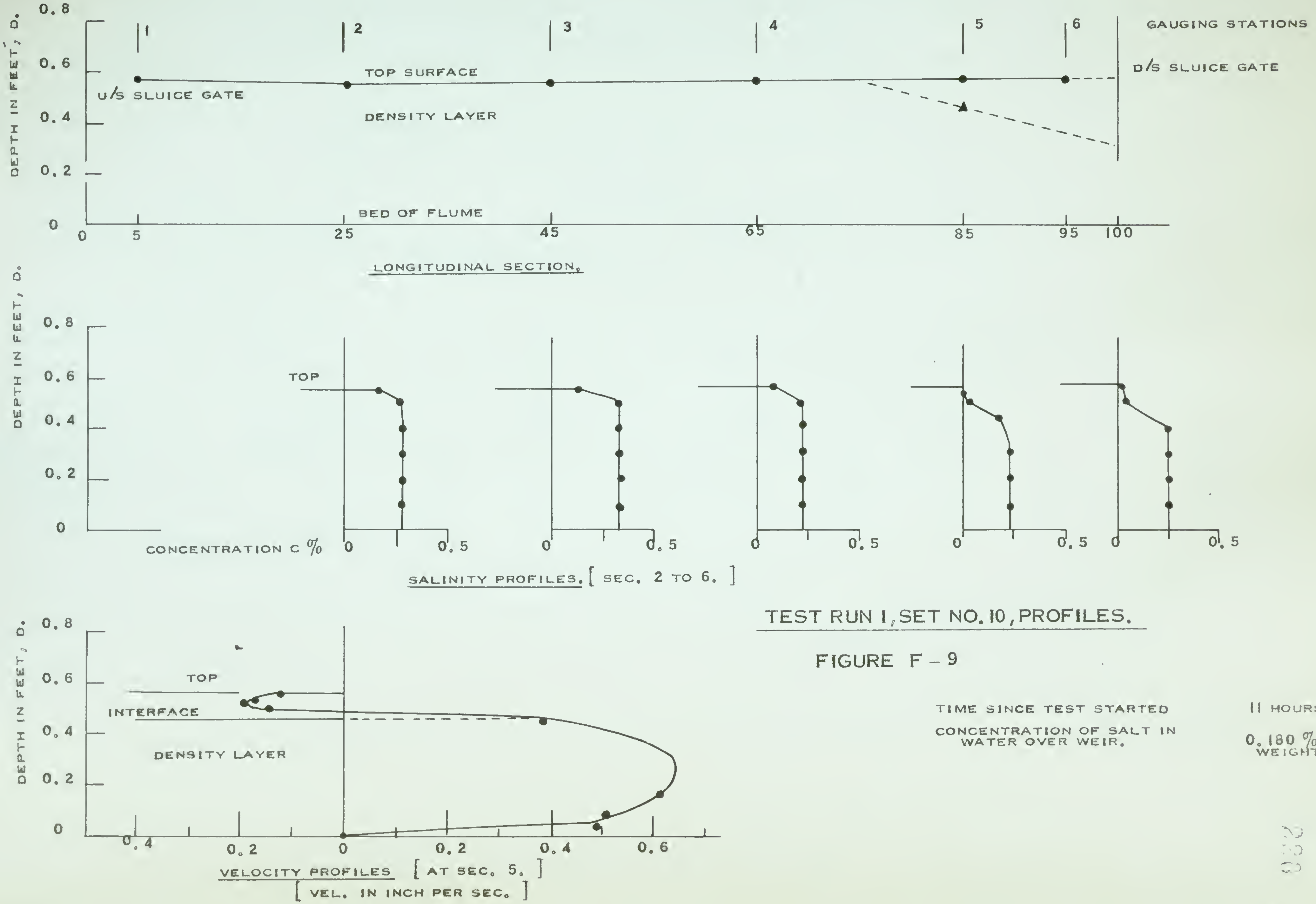


TEST RUN I, SET NO. 7, PROFILES.

FIGURE F – 8

TIME SINCE TEST STARTED 8 HOURS.

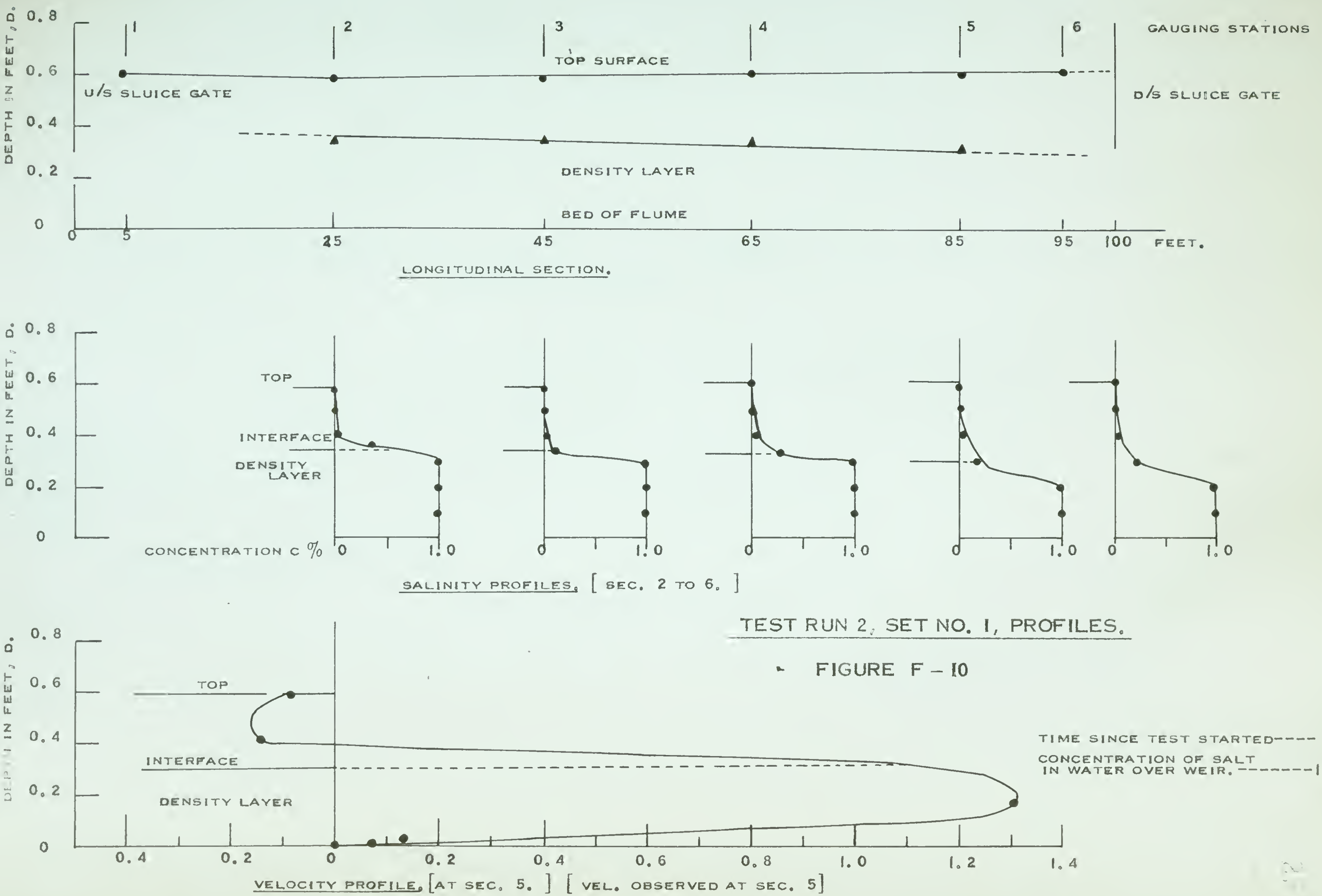
CONCENTRATION OF SALT IN WATER OVER WEIR. 0.182 % BY WEIGHT.



TEST RUN I, SET NO. 10, PROFILES.

FIGURE F – 9

TIME SINCE TEST STARTED	11 HOURS.
CONCENTRATION OF SALT IN WATER OVER WEIR.	0.180 % BY WEIGHT.

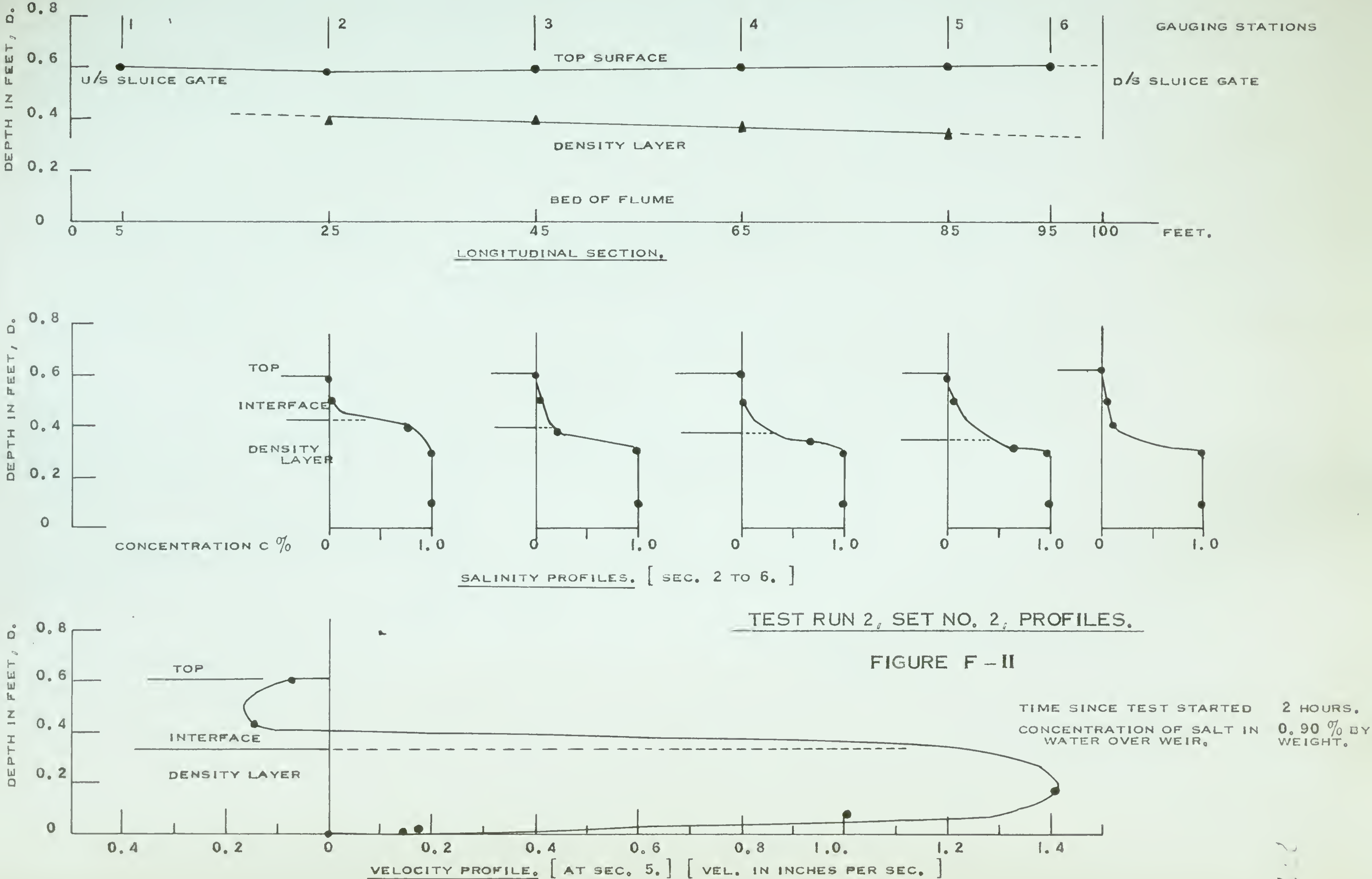


TEST RUN 2, SET NO. 1, PROFILES.

FIGURE F – 10

TIME SINCE TEST STARTED---- 1 HOUR

CONCENTRATION OF SALT IN WATER OVER WEIR.--------1 % BY WEIGHT



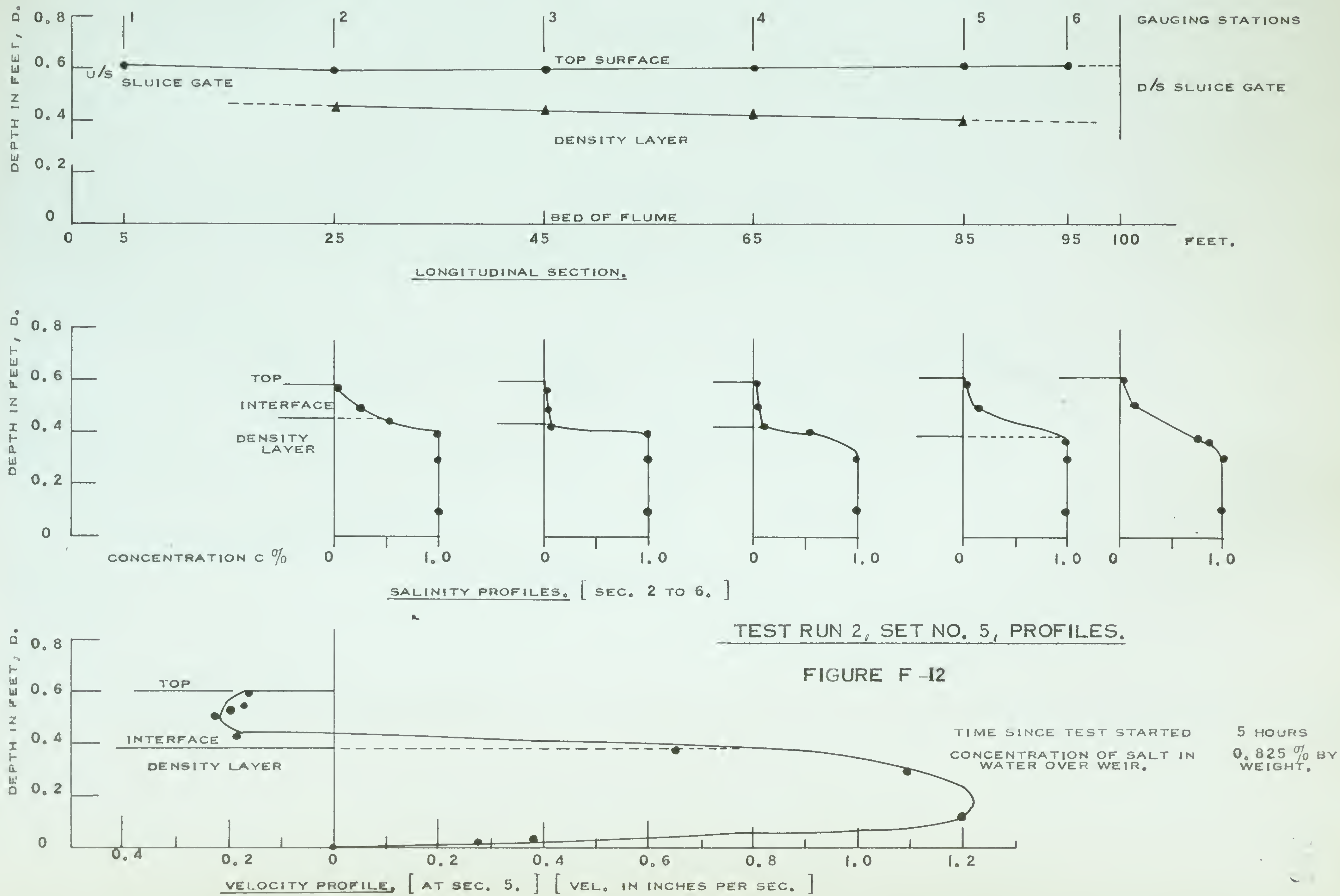
LONGITUDINAL SECTION.

SALINITY PROFILES. [SEC. 2 TO 6.]

VELOCITY PROFILE. [AT SEC. 5.] [VEL. IN INCHES PER SEC.]

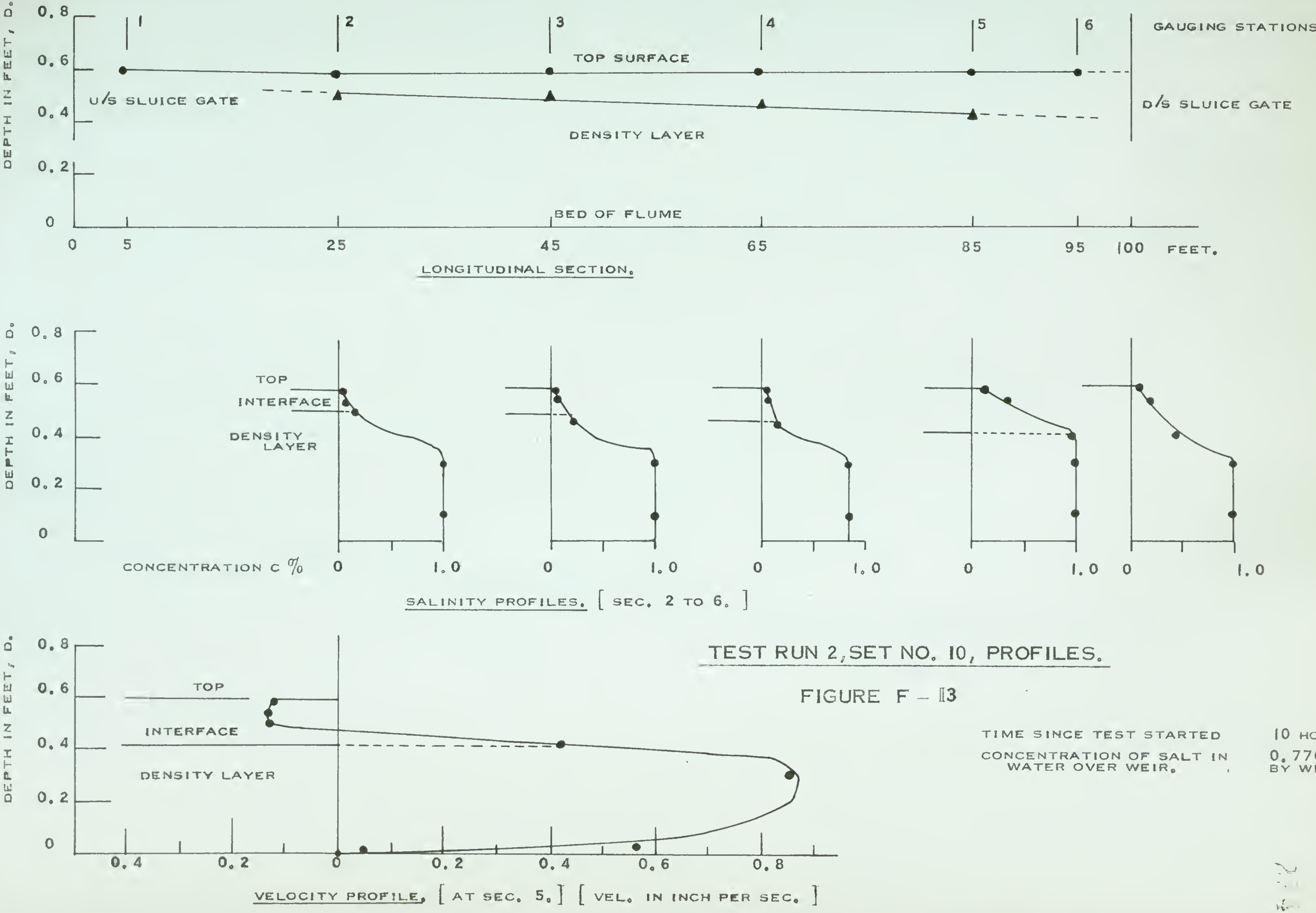
TEST RUN 2, SET NO. 2, PROFILES.

FIGURE F – II



TEST RUN 2, SET NO. 5, PROFILES.

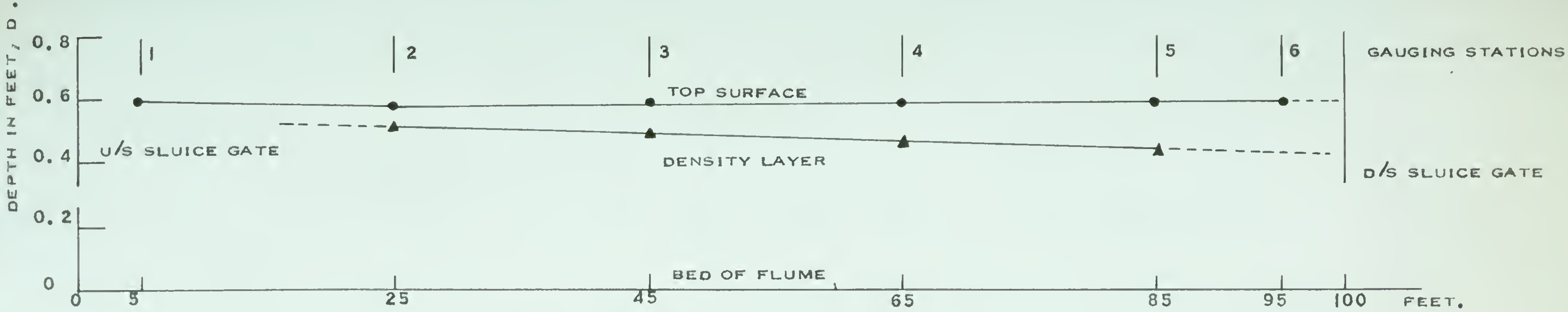
FIGURE F-12



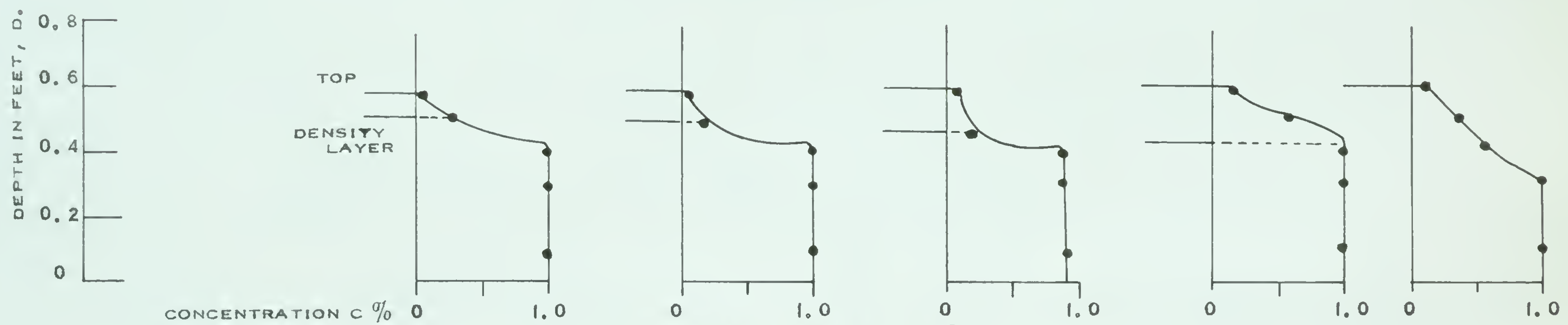
TEST RUN 2, SET NO. 10, PROFILES.

FIGURE F – II3

TIME SINCE TEST STARTED	10 HOURS.
CONCENTRATION OF SALT IN WATER OVER WEIR.	0.770 % BY WEIGHT.



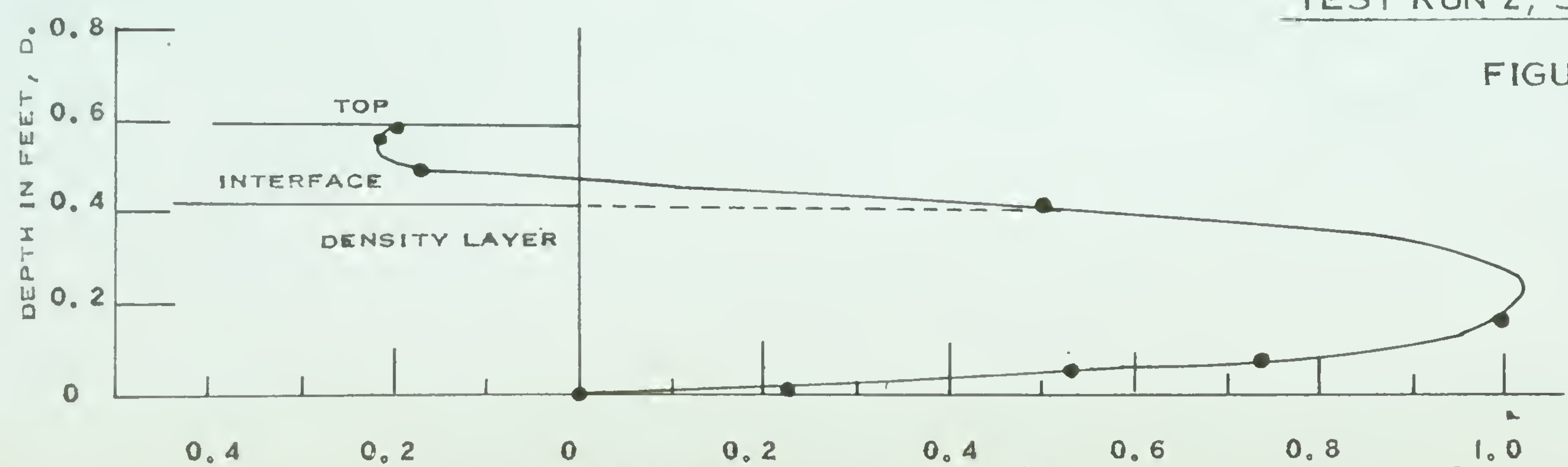
LONGITUDINAL SECTION.



SALINITY PROFILES. [SEC. 2 TO 6.]

TEST RUN 2, SET NO. II, PROFILES.

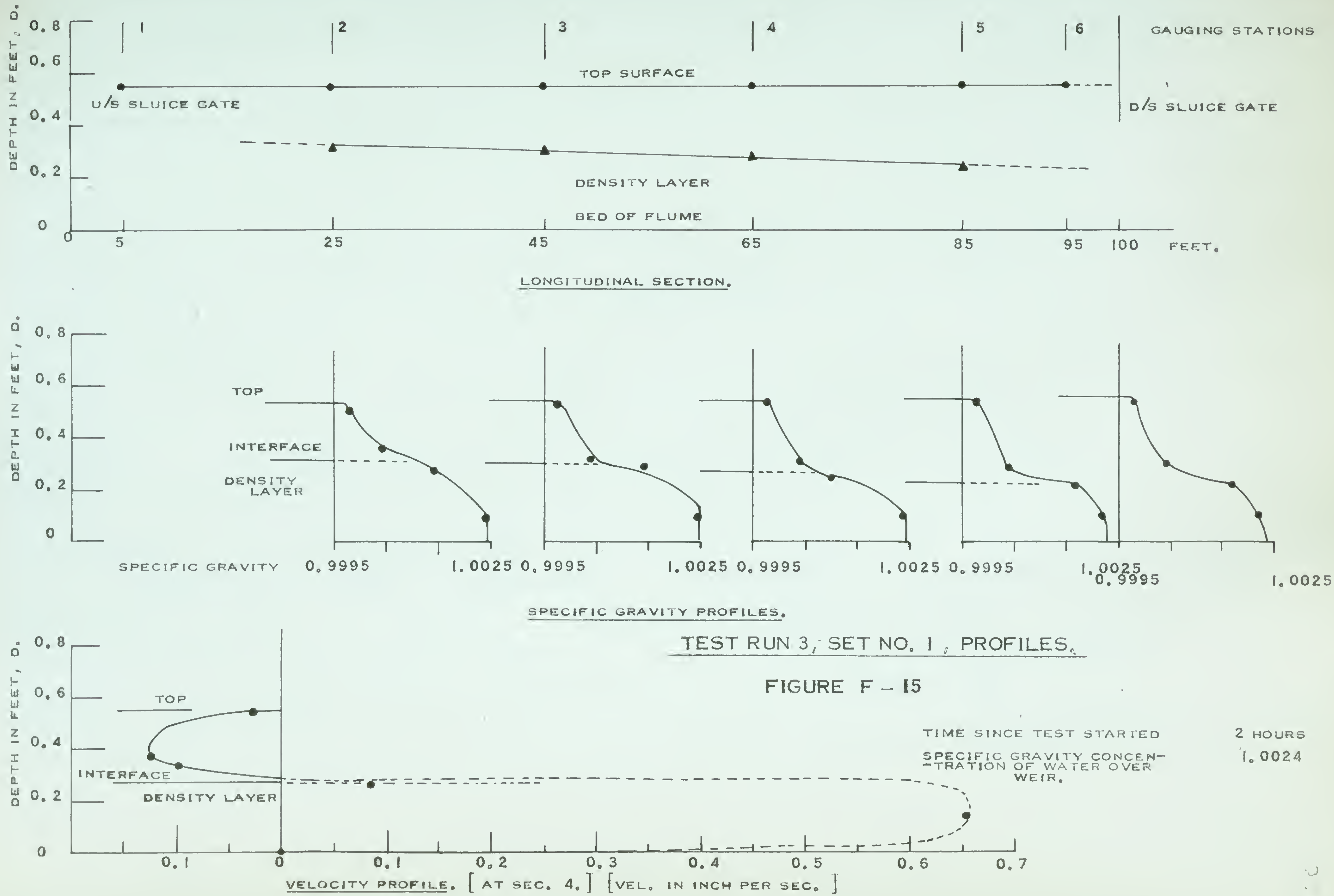
FIGURE F-14



VELOCITY PROFILE. [AT SEC. 5.] [VEL. IN INCHES PER SEC.]

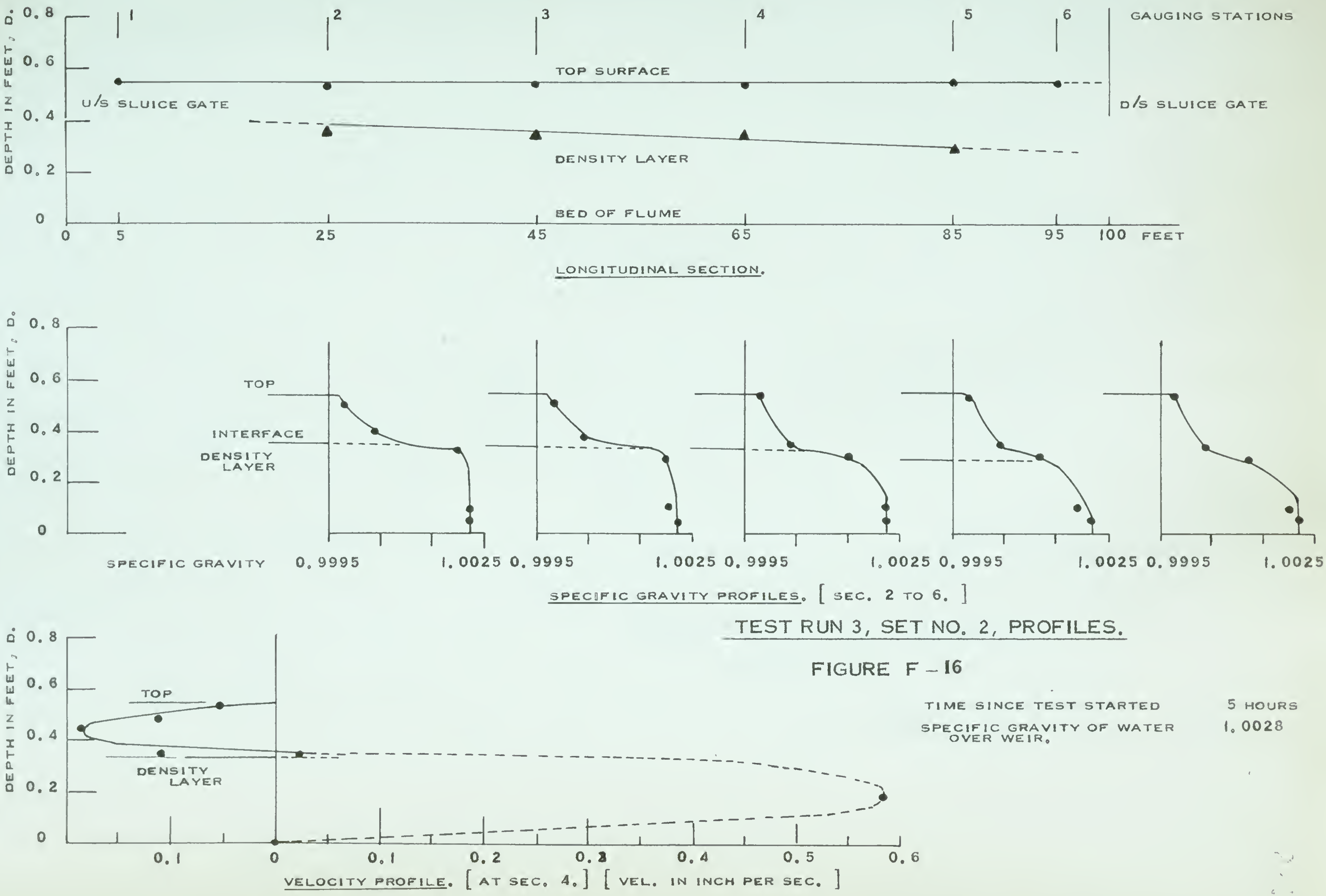
TIME SINCE TEST STARTED 11 HOURS

CONCENTRATION OF SALT IN WATER OVER WEIR. 0.760 % BY WEIGHT.



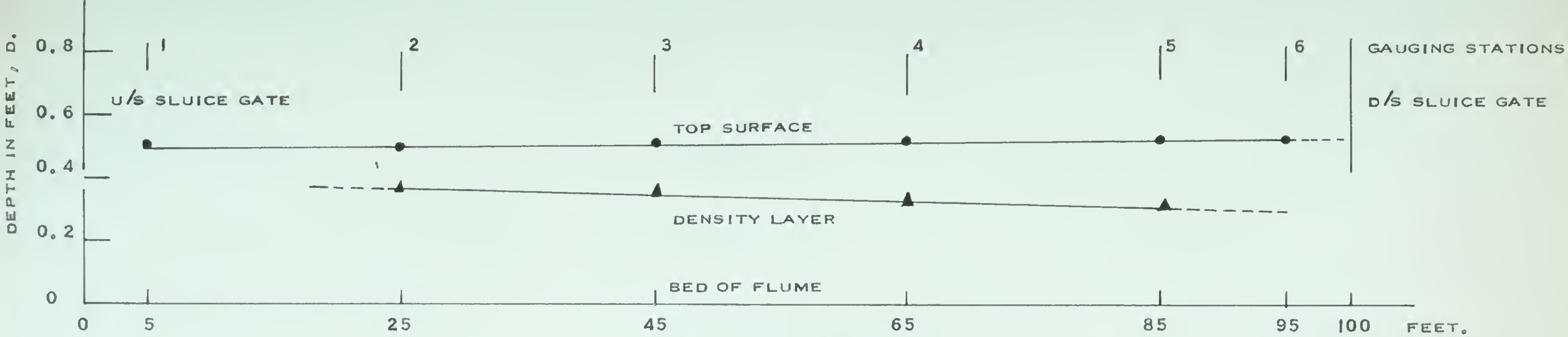
TEST RUN 3, SET NO. 1, PROFILES.

FIGURE F – 15

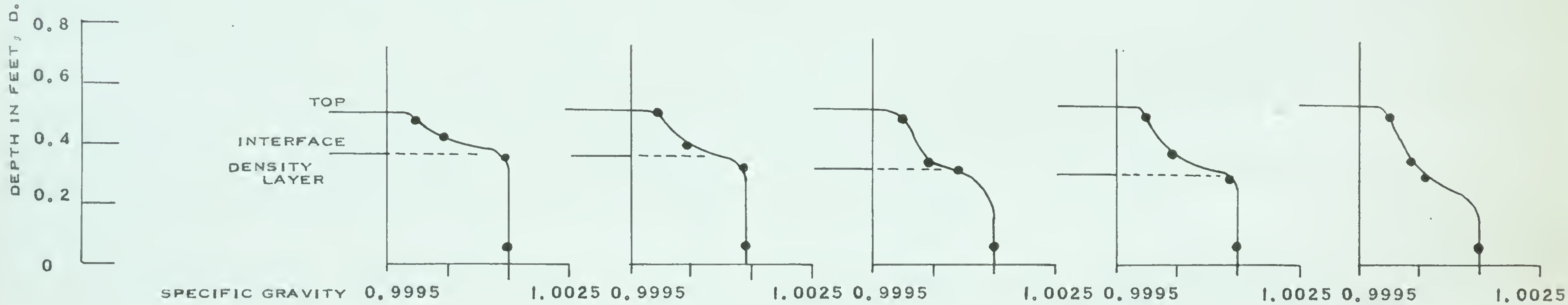


TEST RUN 3, SET NO. 2, PROFILES.

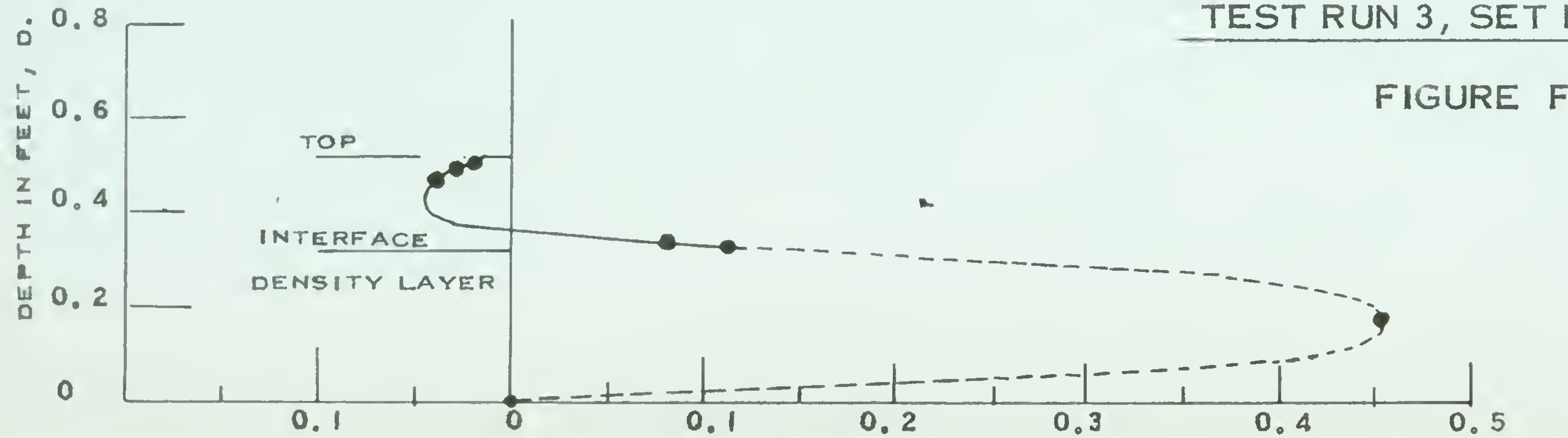
FIGURE F-16



LONGITUDINAL SECTION.



SPECIFIC GRAVITY PROFILES. [SEC. 2 TO 6.]



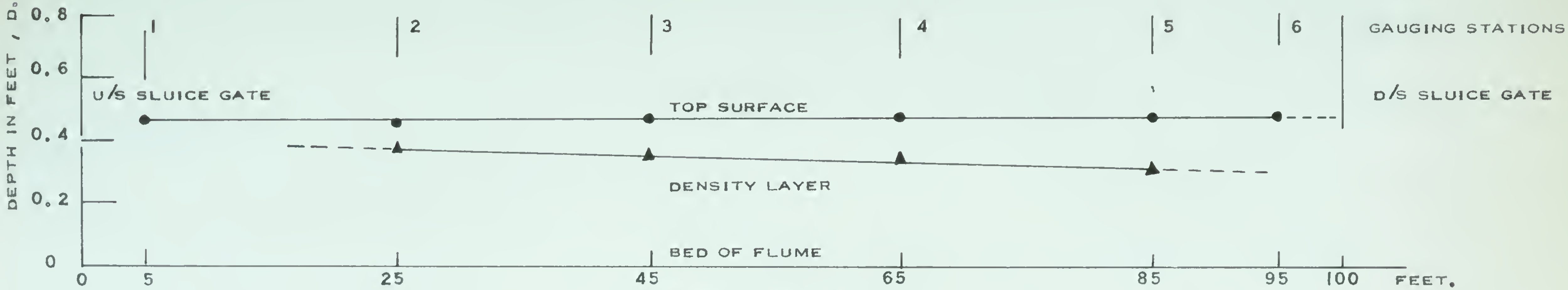
VELOCITY PROFILE. [AT SEC. 4.] [VEL. IN INCH PER SEC.]

TEST RUN 3, SET NO. 4, PROFILES.

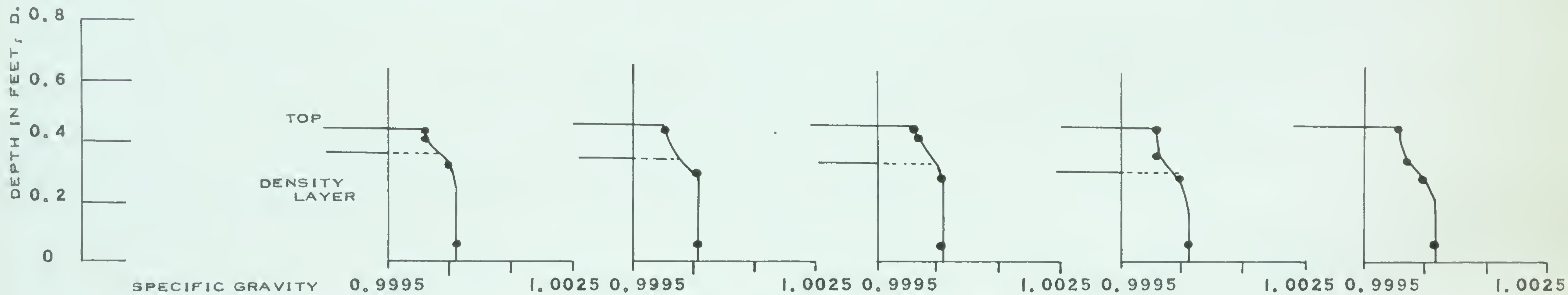
FIGURE F-17

TIME SINCE TEST STARTED 17 HOURS

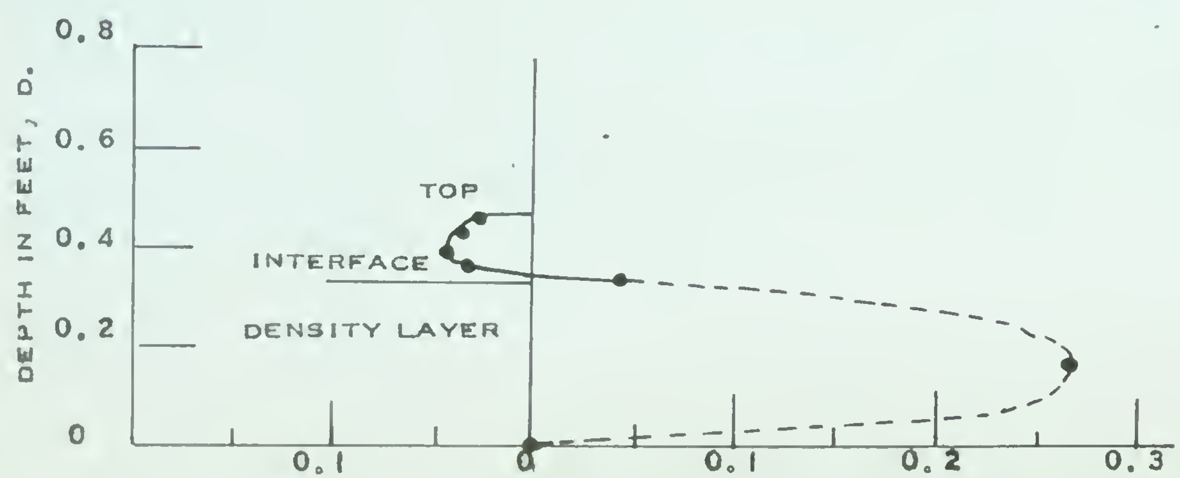
SPECIFIC GRAVITY OF WATER OVER WEIR. 1.0012



LONGITUDINAL SECTION.



SPECIFIC GRAVITY PROFILES. [SEC. 2 TO 6.]

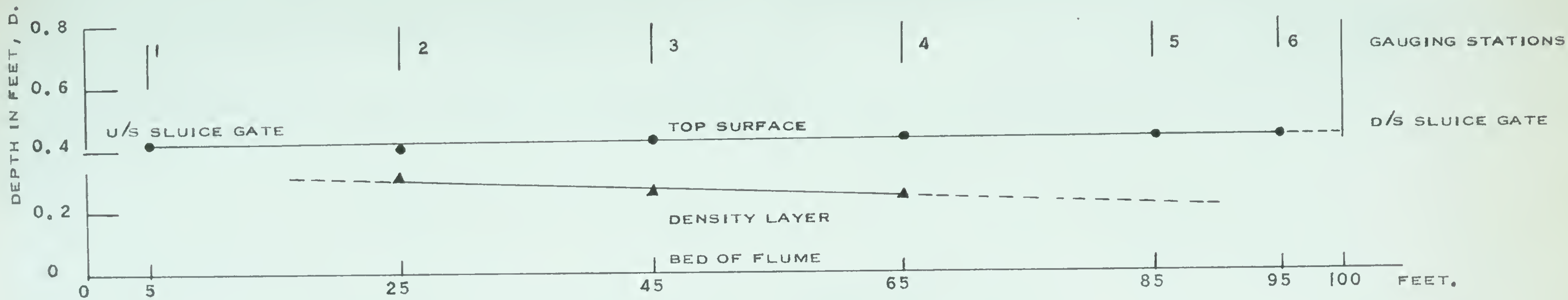


VELOCITY PROFILES, [AT SEC. 4.] [VEL. IN INCH PER SEC.]

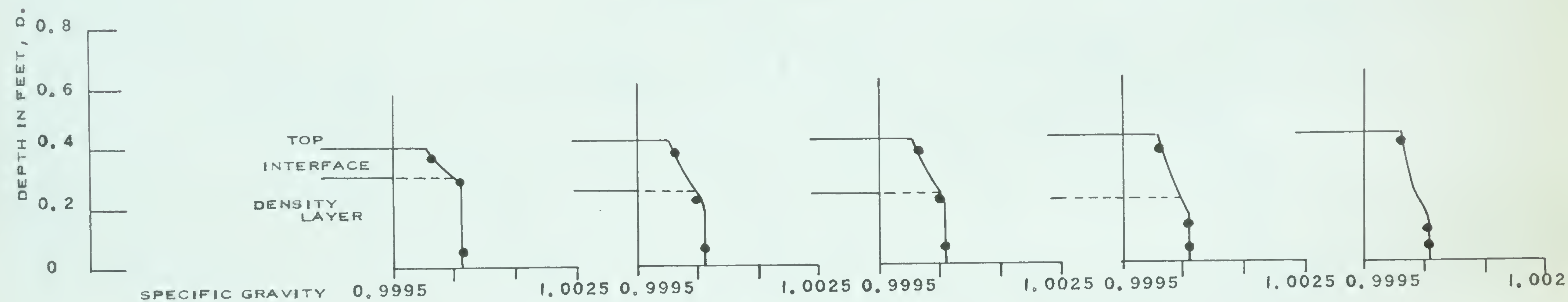
TEST RUN 3, SET NO. 7, PROFILES.

FIGURE F – 18

TIME SINCE TEST STARTED	53 HOURS
SPECIFIC GRAVITY OF WATER OVER WEIR.	1.0005



LONGITUDINAL SECTION.

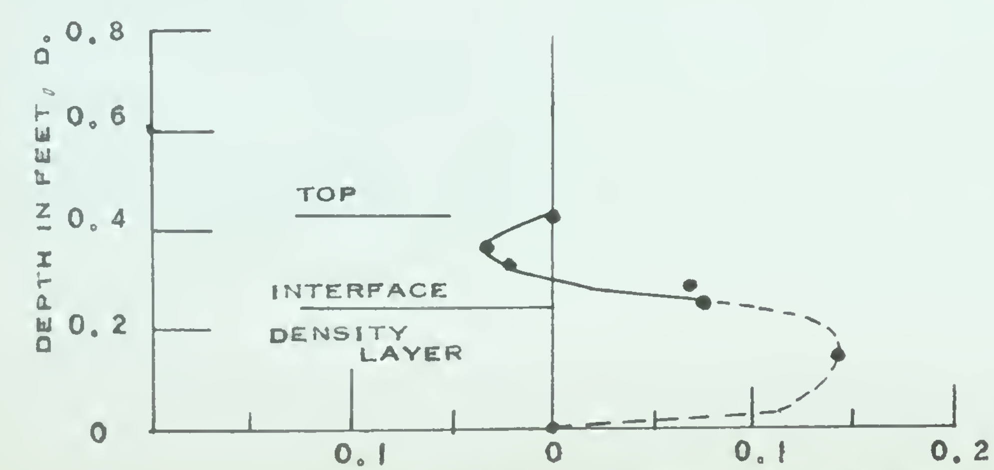


SPECIFIC GRAVITY PROFILES. [SEC. 2 TO 6.]

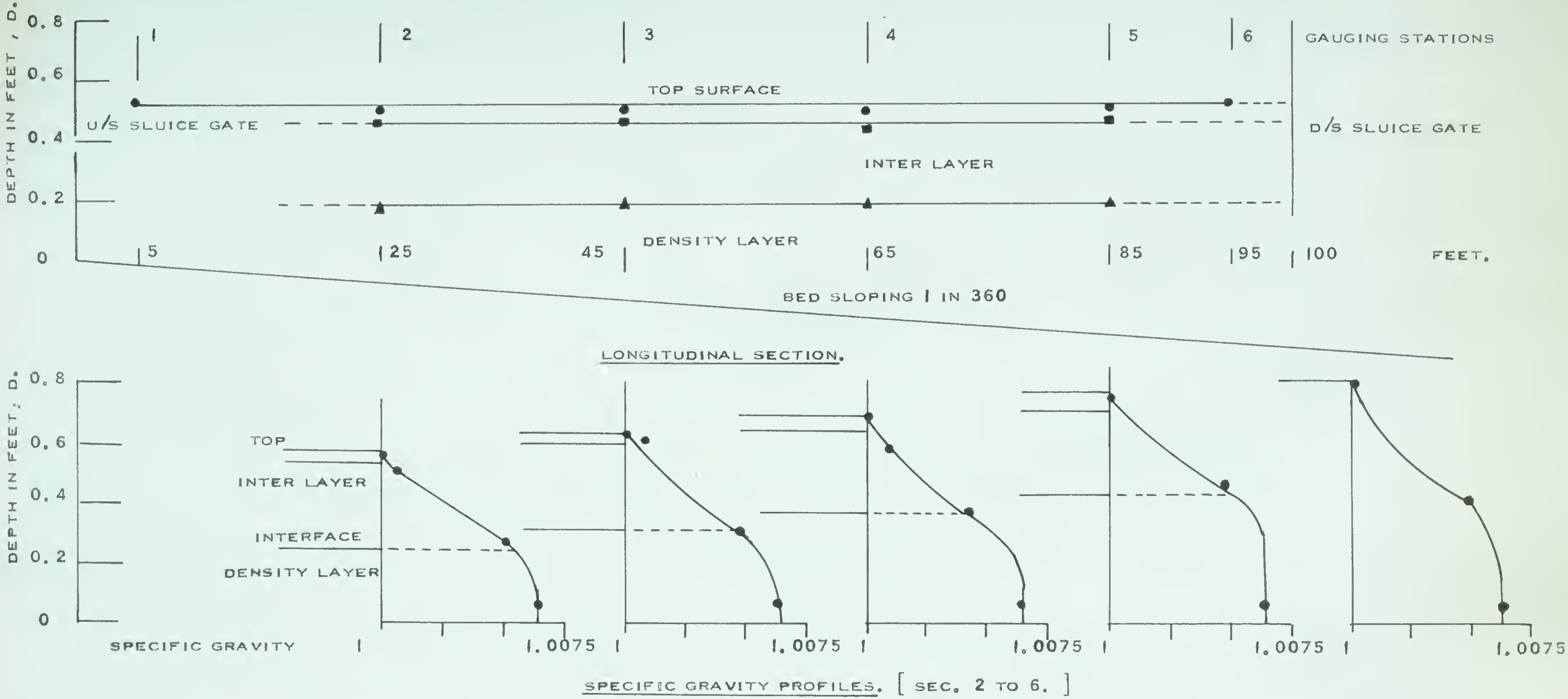
TEST RUN 3, SET NO. II, PROFILES.

FIGURE F - 19

TIME SINCE TEST STARTED	90 HOURS.
SPECIFIC GRAVITY OF WATER OVER WEIR.	1.0004

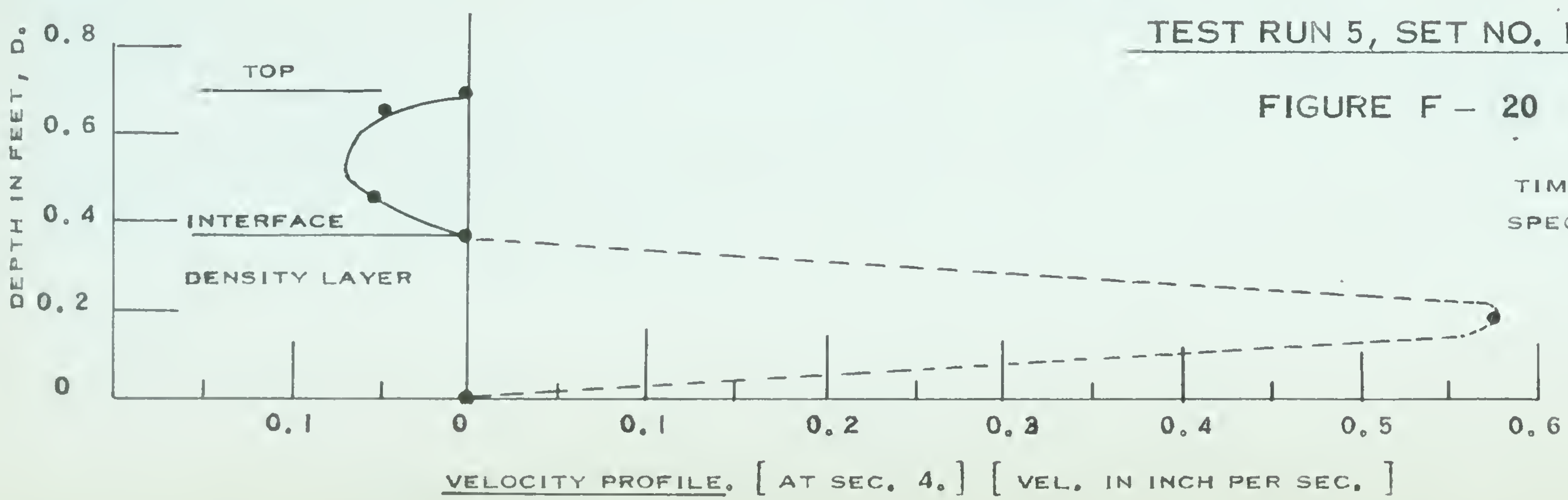


VELOCITY PROFILE. [AT SEC. 4.] [VEL. IN INCH PER SEC.]

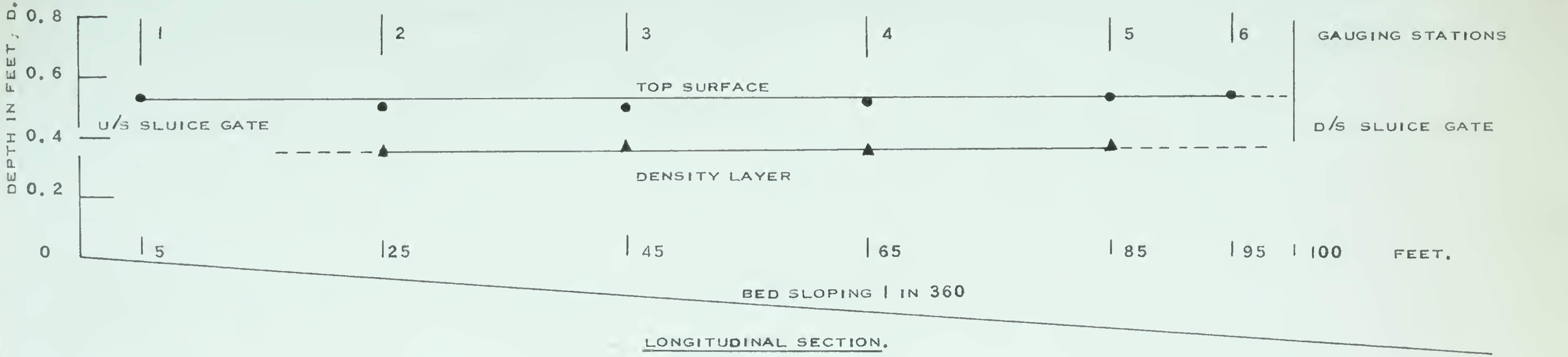


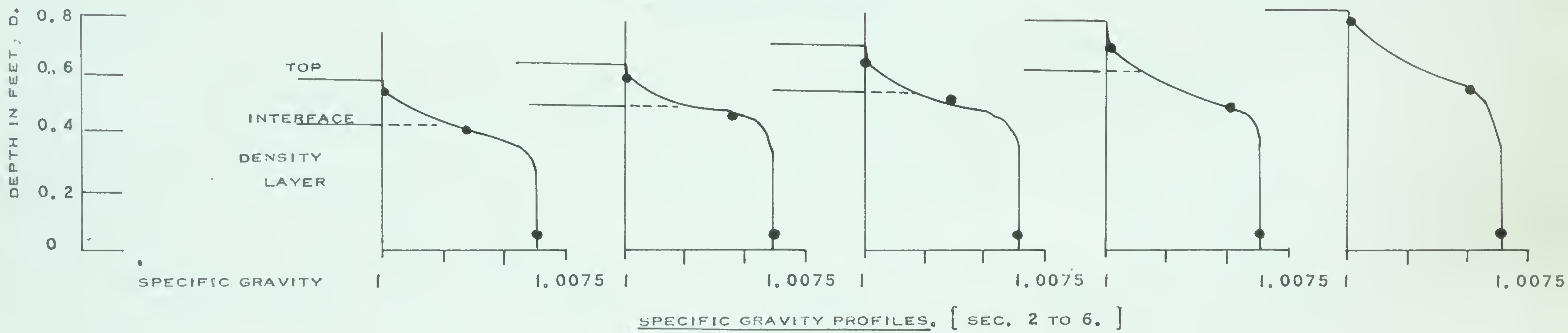
TEST RUN 5, SET NO. 1, PROFILES.

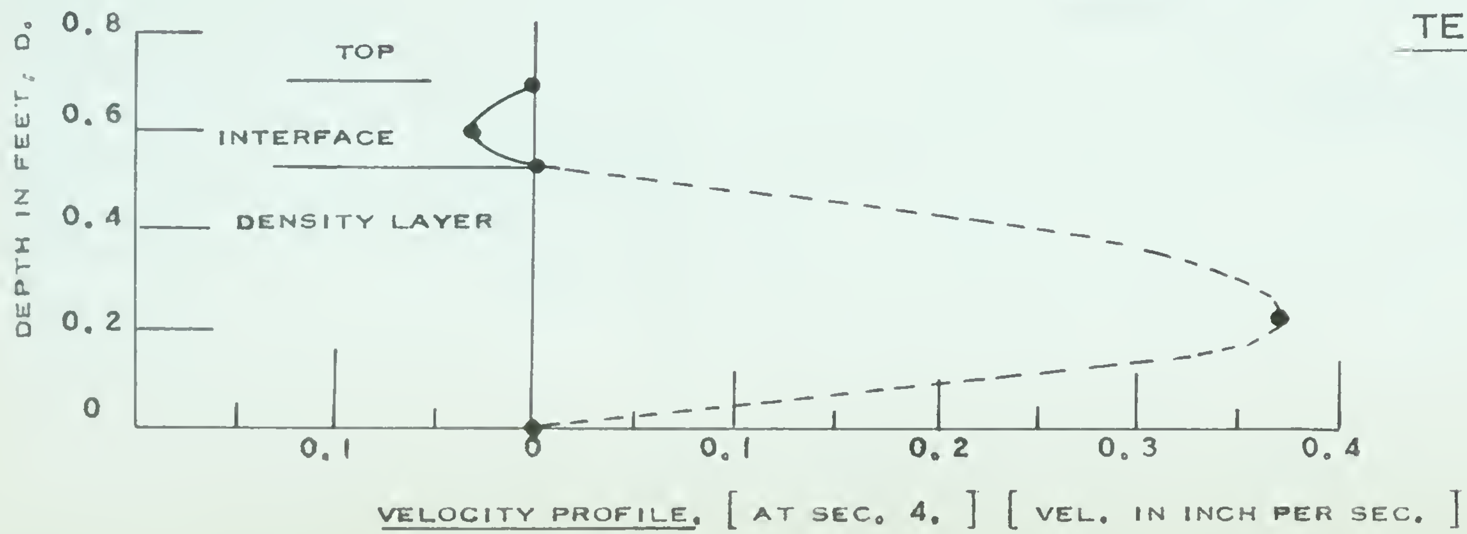
FIGURE F – 20



TIME SINCE TEST STARTED	2 HOURS
SPECIFIC GRAVITY OF WATER OVER WEIR.	1.0075



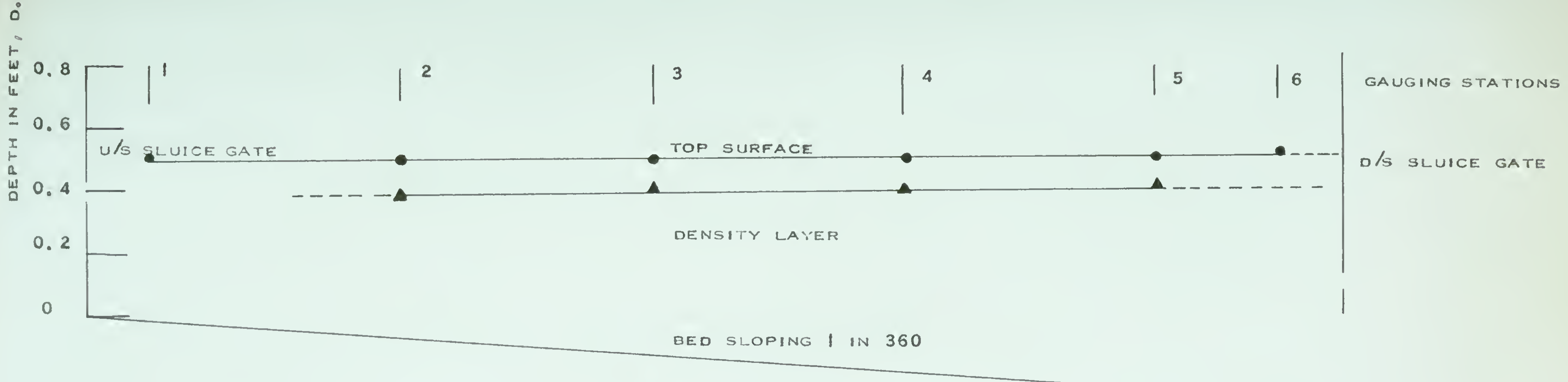




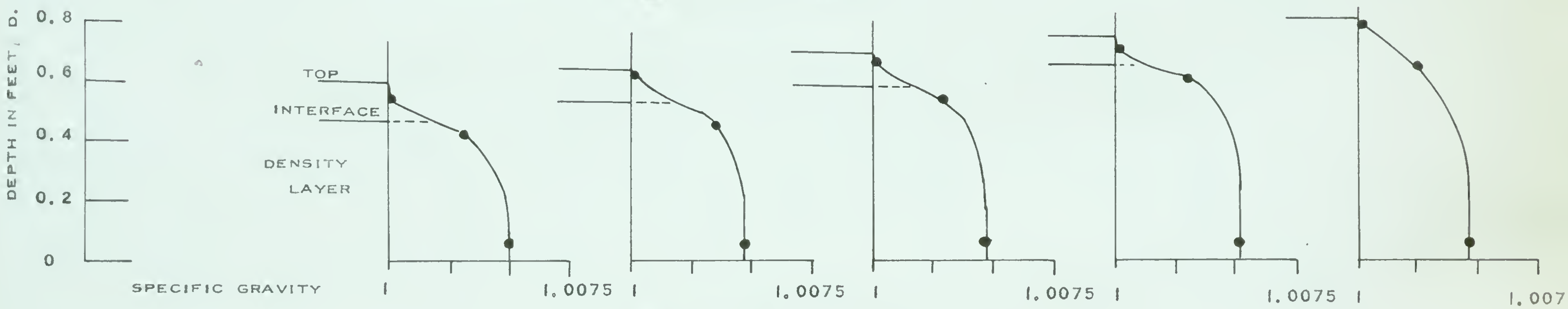
TEST RUN 5, SET NO. 2, PROFILES.

FIGURE F-21

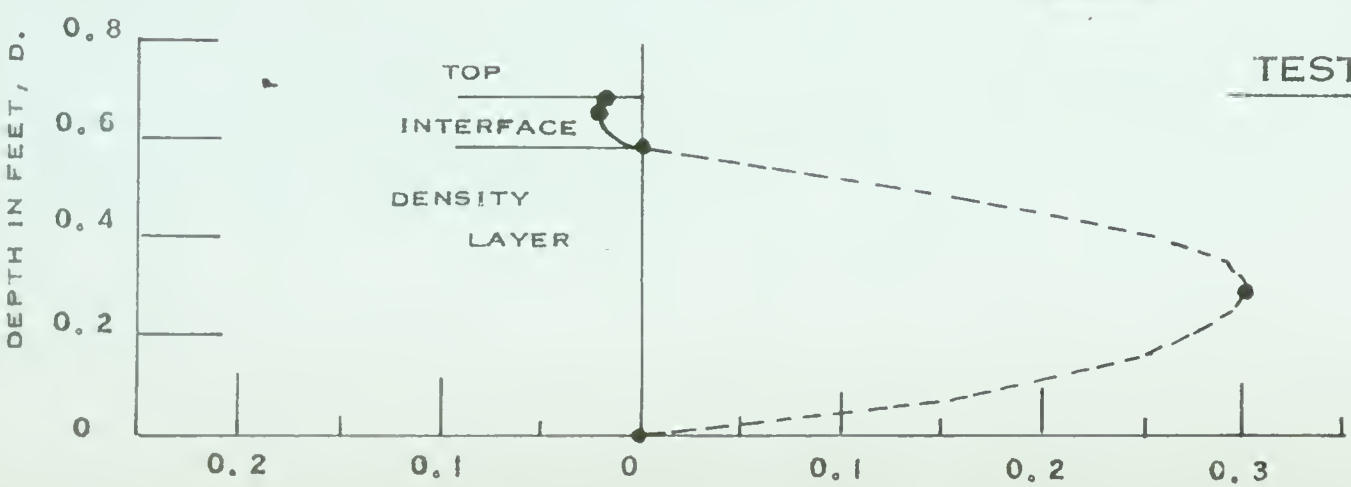
TIME SINCE TEST STARTED	4 HOURS
SPECIFIC GRAVITY OF WATER OVER WEIR	1.0065



LONGITUDINAL SECTION.



SPECIFIC GRAVITY PROFILES. [SEC. 2 TO 6.]

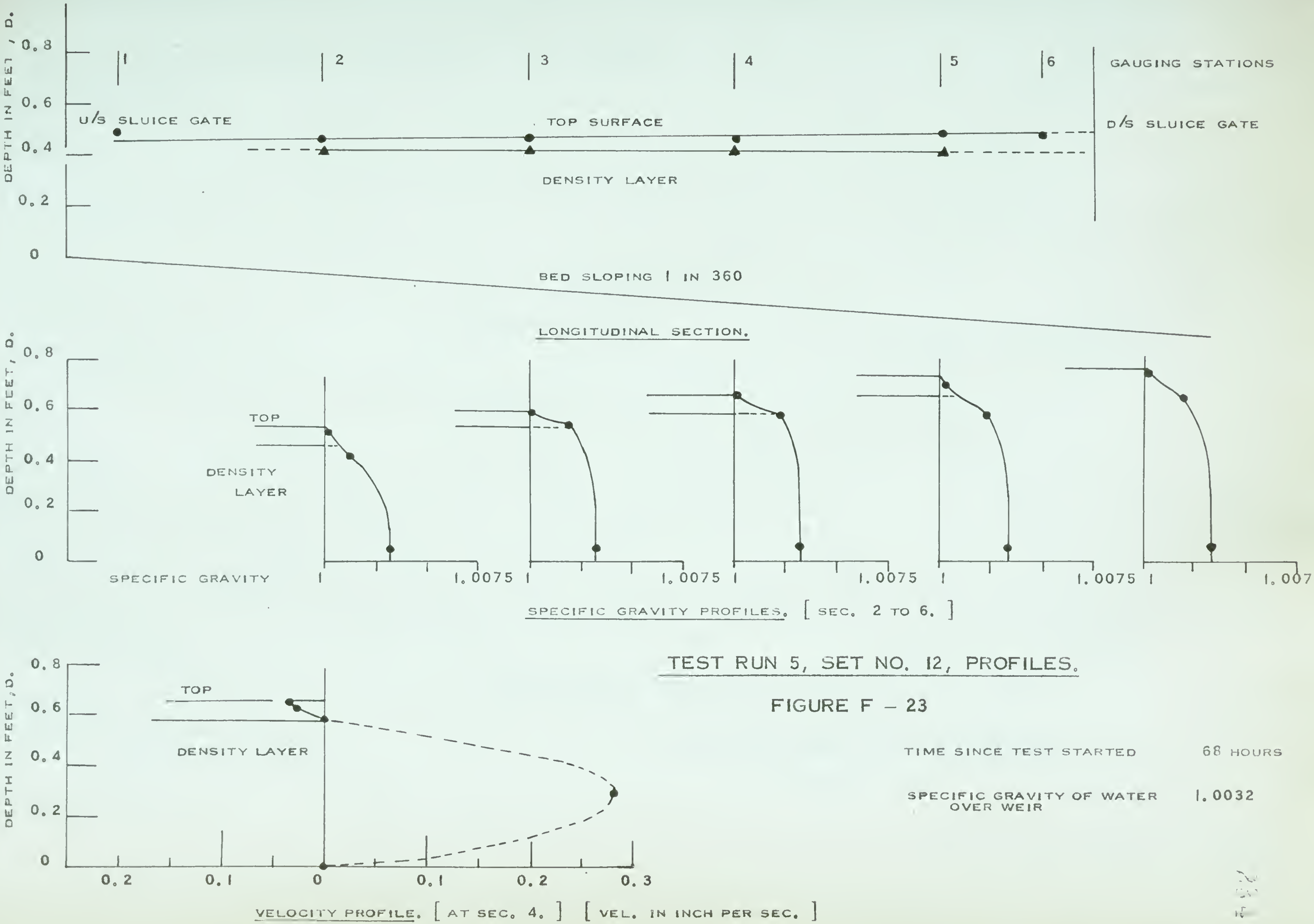


VELOCITY PROFILE. [AT SEC. 4.] [VEL. IN INCH PER SEC.]

TEST RUN 5, SET NO. 6, PROFILES.

FIGURE F – 22

TIME SINCE TEST STARTED	24 HOURS
SPECIFIC GRAVITY OF WATER OVER WEIR.	1.0047

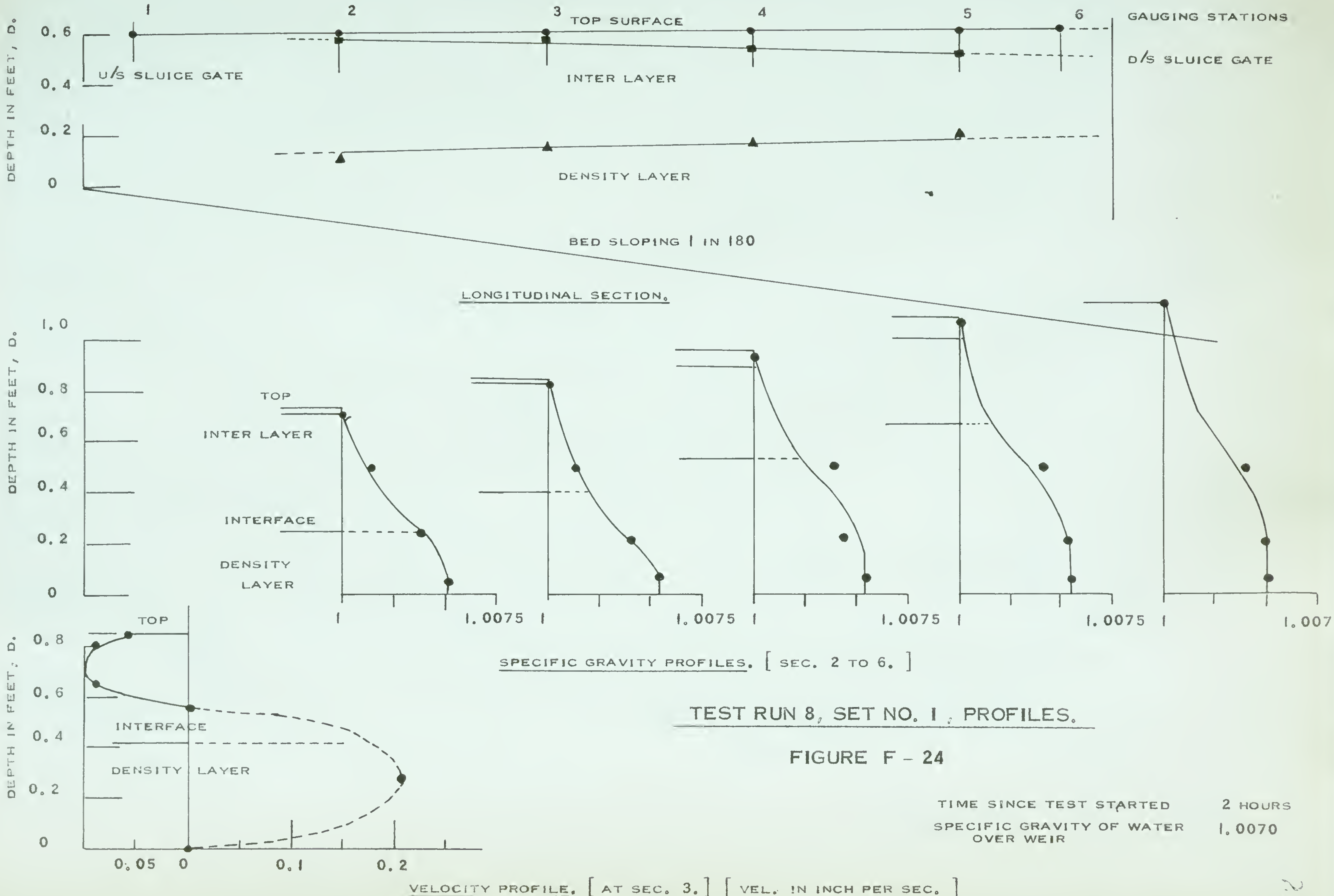


TEST RUN 5, SET NO. 12, PROFILES.

FIGURE F – 23

TIME SINCE TEST STARTED 68 HOURS

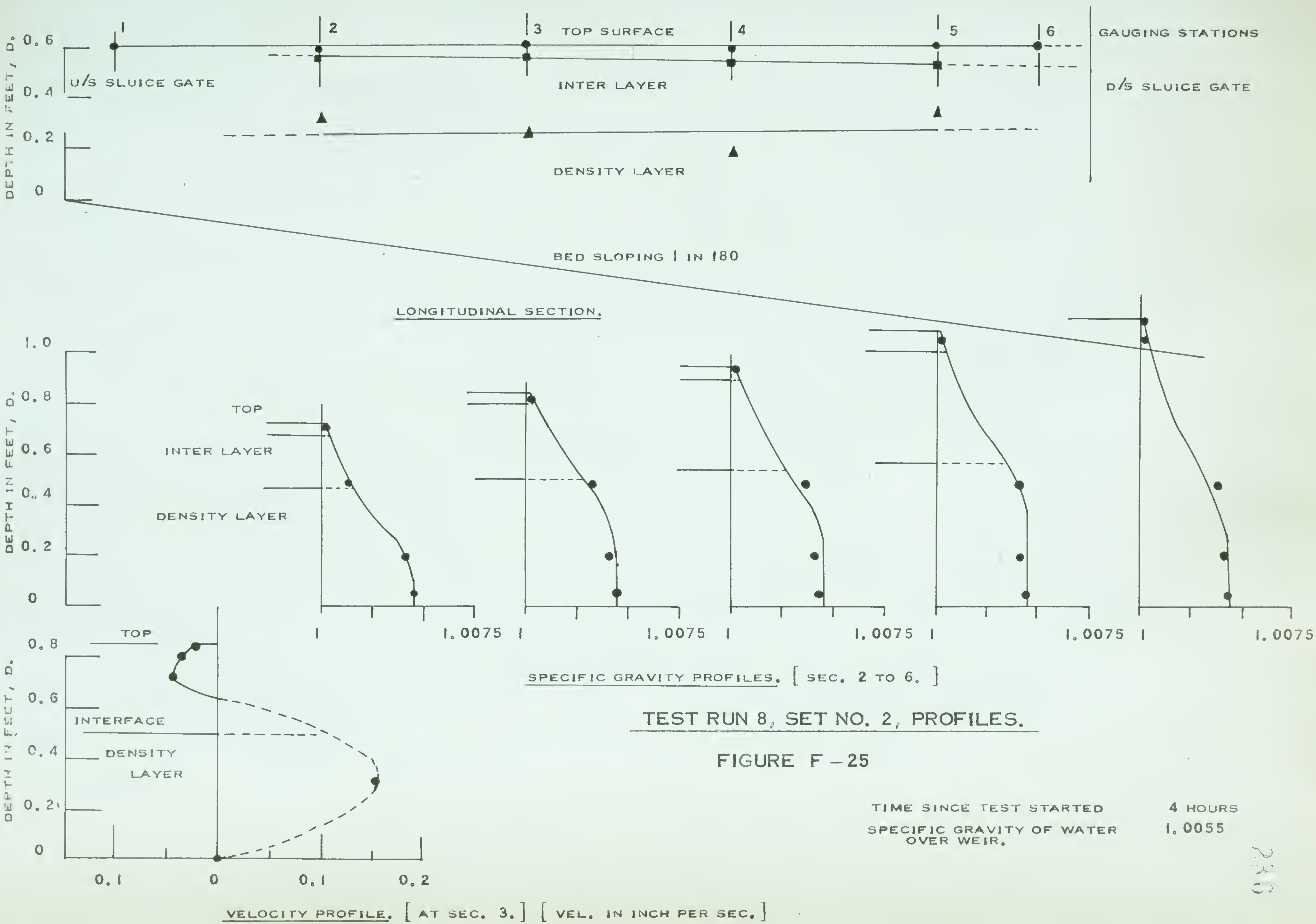
SPECIFIC GRAVITY OF WATER OVER WEIR 1.0032



TEST RUN 8, SET NO. 1 , PROFILES.

FIGURE F - 24

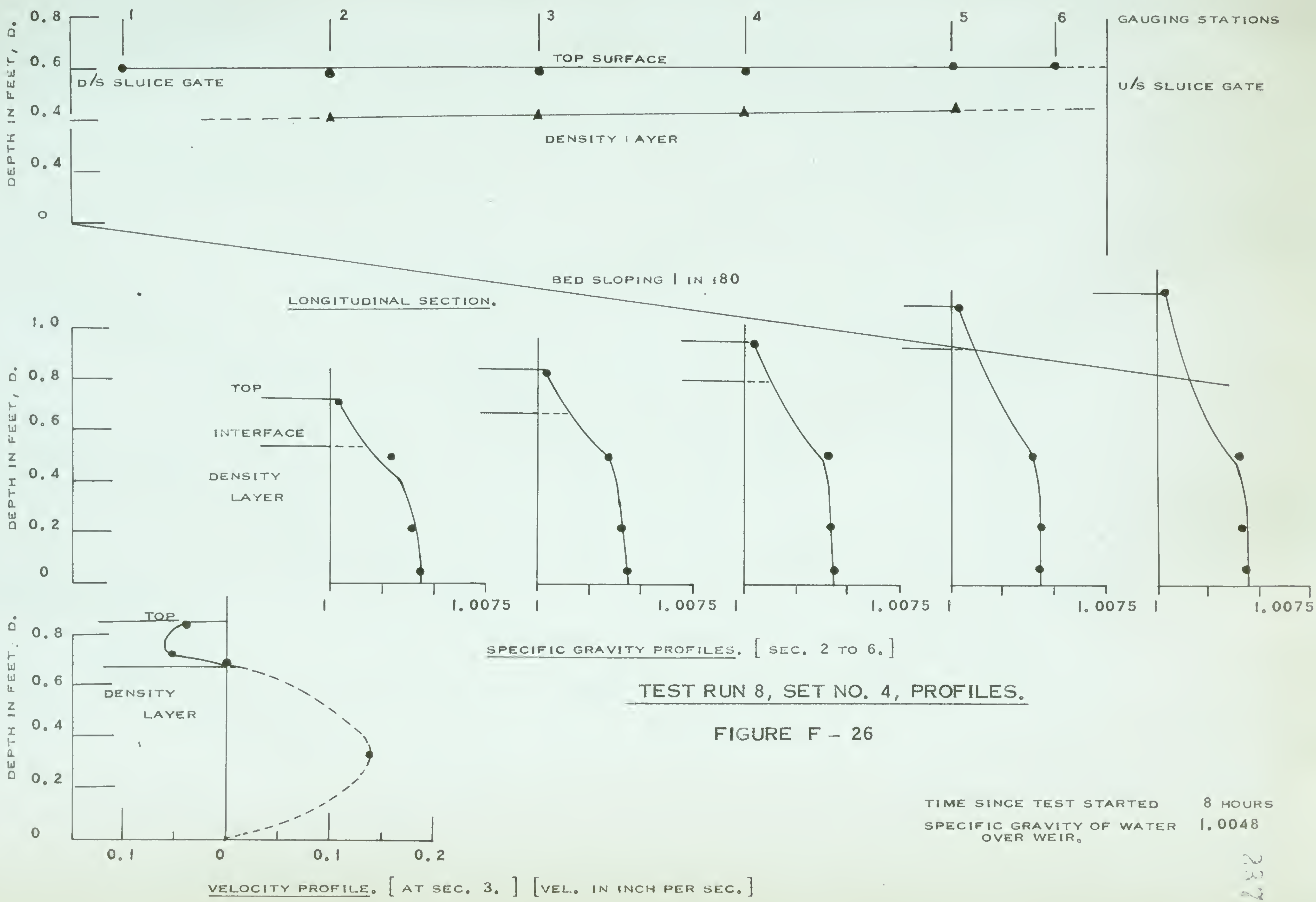
TIME SINCE TEST STARTED	2 HOURS
SPECIFIC GRAVITY OF WATER OVER WEIR	1.0070



TEST RUN 8, SET NO. 2, PROFILES.

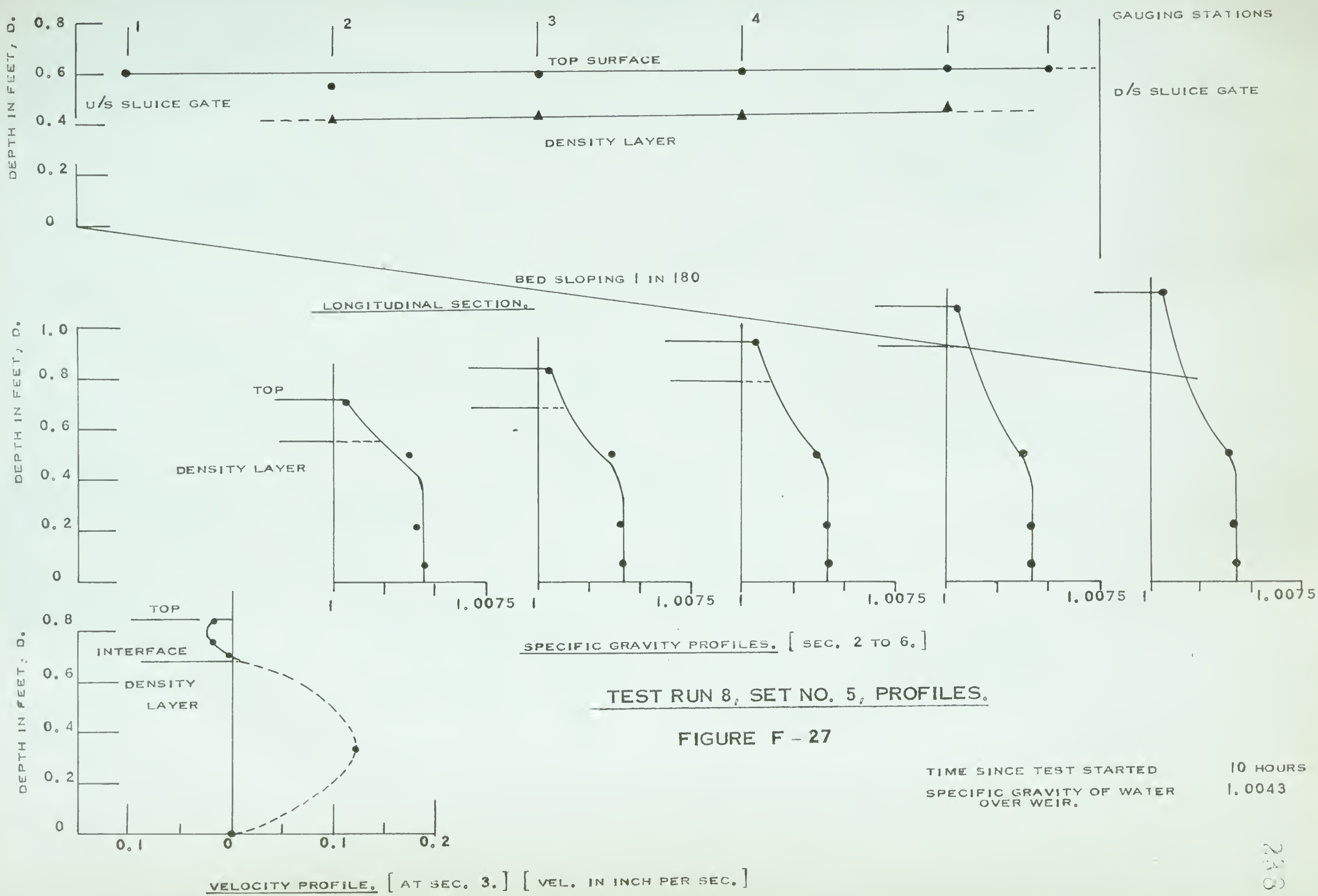
FIGURE F – 25

TIME SINCE TEST STARTED	4 HOURS
SPECIFIC GRAVITY OF WATER OVER WEIR.	1.0055



TEST RUN 8, SET NO. 4, PROFILES.

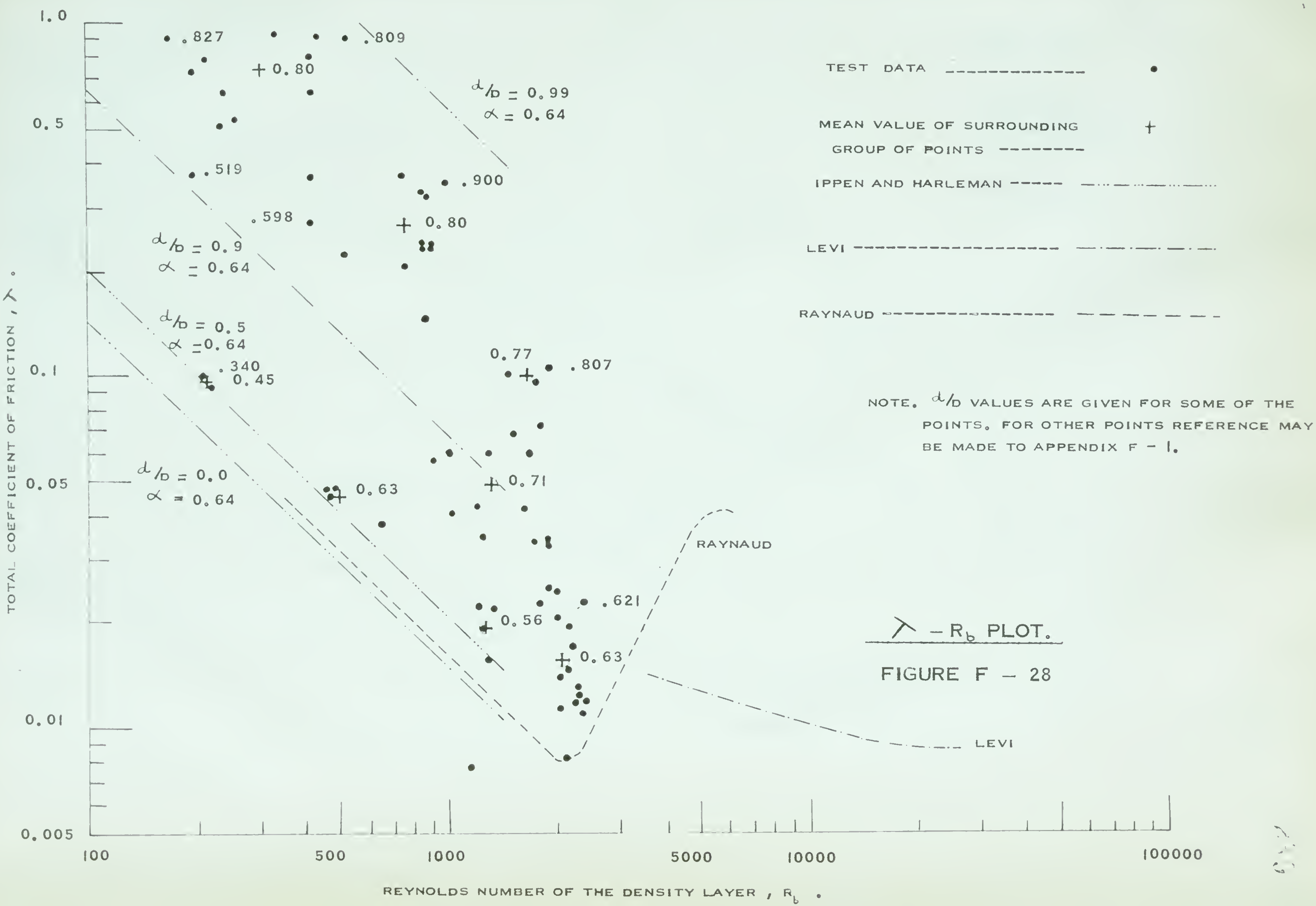
FIGURE F – 26



TEST RUN 8, SET NO. 5, PROFILES.

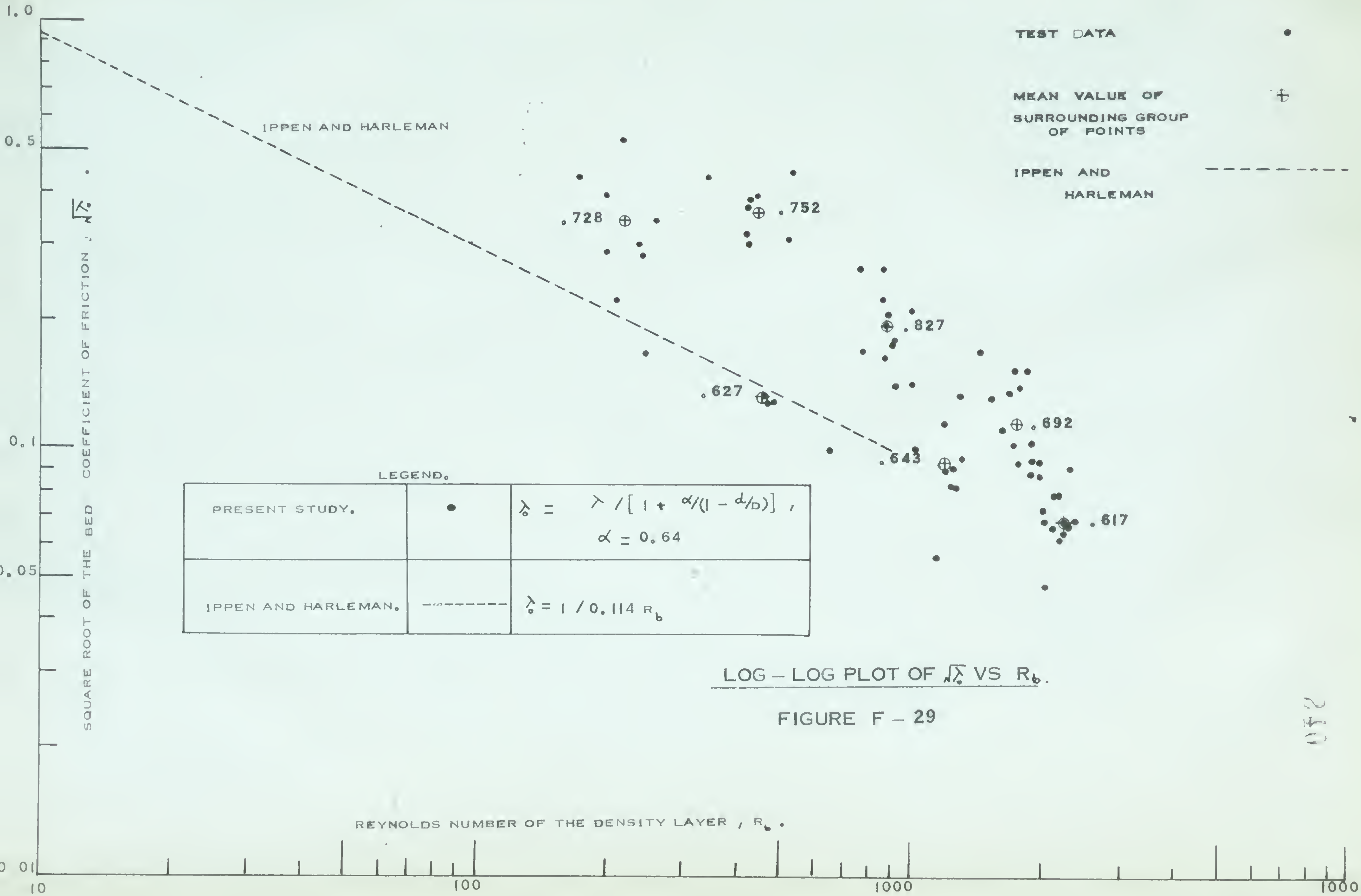
FIGURE F - 27

TIME SINCE TEST STARTED	10 HOURS
SPECIFIC GRAVITY OF WATER OVER WEIR.	1.0043



$\lambda - R_b$ PLOT.

FIGURE F – 28



LOG – LOG PLOT OF $\sqrt{\lambda_o}$ VS R_b.

FIGURE F – 29

240